University Of Canterbury

Analysis Of Forecasted Travel Time Benefits Against Those Realised

By
Akhylesh (Kesh) Keshaboina

Supervisor: Glen Koorey
Senior Lecturer in Transportation Engineering

Co-supervisor: Alan Nicholson
Director of Transportation Engineering

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Dept. of Civil & Natural Resources Engineering
University of Canterbury
Private Bag 4800
Christchurch, New Zealand

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Abstract

There is lack of knowledge on how well the transport projects work once implemented. This research project seeks to investigate how the forecasted benefits claimed during the economic appraisal of the projects compare with the actual benefits realised. This study carried out a literature review on how the travel time benefits are forecasted for transport investment projects and comments on general to specific issues like value of travel time, international and local experiences of forecasting travel time savings to use of traffic modelling in forecasting travel time savings.

The study also carried out a post-construction evaluation of projects on a diverse range of transport projects from realignments, grade separated interchange to the installation of HOV lanes and urban bypass project. Post-construction analysis was carried out and then compared against those assumed for the pre-construction evaluation and possible reasons for the differences were discussed.

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Table of Contents

1 Introduction

1.1 Overview

In most of the transport infrastructure investments worldwide, either in developed or developing nations, reduction in travel time and the associated benefits plays an important role and in many cases constitutes a major project objective. These benefits are often determined as part of cost benefit analysis. However, there is little or not much work done on how the forecasted benefits claimed during the economic appraisal of the projects compare with the actual benefits realised.

This research reviews the work on issues related to forecast of travel time benefits for the investment of transport infrastructures. From general to specific issues, the review comments on value of travel time, factors affecting travel time, issues associated with forecast of travel time savings using traffic modelling outputs and international findings on the differences in forecasted travel time savings to those realised.

1.2 Objectives of Thesis Project

The objectives of this research are

- An assessment of the forecasted travel time benefits to those realised for a range of infrastructure development schemes, in particular to the roading schemes which are aimed to reduce travel time and congestions.
- An assessment of current New Zealand practices of forecasting travel time benefits compared with other international practices through a literature review.

This first objective noted above will be achieved by identifying case study sites for a range of infrastructure projects and reviewing the respective Scheme Assessment Reports (SAR's) and the data used during the project economic appraisal (pre-construction). The key economic appraisal data and tools used to carry out the pre-construction appraisal will be identified to undertake post-construction traffic surveys such that a reasonable level of comparison can be made. Followed by this an analysis of post-construction traffic surveys will be carried out to determine post-construction travel time benefits. Wherever possible, consistency would be maintained between pre-construction and post-construction methodologies.

1.3 Limitations of the Study

- The calibrated (latest version) traffic models (TG SATURN model and the WICB SATURN model) used in this study are assumed to accurately represent the existing network conditions and henceforth, were used as a tool to determine the travel time benefits of the identified study sites.
- Traffic modelling of the do minimum scenario (removing the scheme from the latest calibrated SATURN models) did not involve any further calibration as the process will involve extensive and time consuming modelling inputs and it would be beyond the timelines of research project of this scale.

- Post-construction appraisal is limited to travel time benefits only.
- The appraisal does not include analysis of cyclist/pedestrian travel time benefits, safety benefits and other transport benefits (e.g. vehicle operating costs, trip reliability etc.)

1.4 Structure of Report

The report is set out as follows:

Section 2 of this report summarises the literature reviewed on issues related to forecast of travel time benefits for the investment of transport infrastructures. From general to specific issues, the review comments on value of travel time to issues associated with the use of traffic models in forecasting travel time benefits.

Section 3 details the methodology adopted for this study and the identified study sites.

Section 4 summarises the pre-construction analysis and post-construction analysis for each study sites. This includes a discussion on issues and the outcomes of the analysis.

Section 5 included conclusions of the study.

Section 6 outlines the recommendations for future research.

Section 7 gives the references used for this research followed by appendices.

2 Literature Review

Little research has found which compared how the forecasted benefits claimed during the economic appraisal with actual benefits realised (post completion of projects). This research review discusses the different issues related to forecast of travel time benefits. The review firstly gives an insight in to the travel time values used to determine travel time benefits and the basis on which they are calculated. Following this, a discussion on overseas and local experiences of post evaluation of travel time has been carried out. In addition, a brief discussion on use of traffic models to forecast travel time benefits has also been presented.

It should be noted that the literature review includes how the travel time is valued locally and overseas. This was to get a broad-brush insight on how an actual value (or cost) is assigned for any reduction of travel time for the transport users and outlines briefly on any issues associated with value of travel time. This task does not drill in detail the issues related to valuing travel time as it is acknowledged that there is plenty of international literature and debate on how the travel time values should be valued. It should be noted that it is beyond the scope of this review to comment on the correct values of travel time (VTT) that should be used in the evaluation of transport projects and the methodologies to determine such values.

2.1 Economic Analysis/ travel time benefits

Benefits from transport investment projects accrue mainly from travel time benefits apart from investments to improve road safety. For example, a new road or improvement that is shorter, the travel distances and allows motorists to go faster will generate travel time benefits to the motorists using it. These benefits were traditionally analysed by either a set hand calculation procedures or by the use of outputs from calibrated traffic models.

In the context of New Zealand, NZTA's Economic Evaluation Manual (EEM) is used as a main source of guide to determine travel time benefits. The EEM contains set procedures (simplified procedures and full procedures) to determine travel time benefits of the transport investment projects. This includes guidance on acceptance of traffic models in relation to calibration and validation criteria.

2.1.1 Value of Travel Time

Valuation of travel time has been a much-debated topic world wide. The earliest and the first appropriate methods of valuing travel time savings were carried out by Beesley(1965). Since then many economic theories have been proposed and argued by the transport economists and researchers worldwide. The debates ranged on variety of topics like methodologies of how the travel times should be valued to specific issues like the choice of empirical model estimates (multinomial logit models, mixed logit models) to use of stated preference surveys or revealed preference surveys and other heterogeneity of travel times.

Corotis(2007) comments that: *because of wide diversity of transportation users, assigning value to user time saved is complex. A TRB study summarises these issues as follows " In* *concept, how people value time spent in travel depends on the mode of travel, the purpose of the travel, the trip component, the total time, socio economic characteristics and other preferences" (TCRP, 2002).*

A discussion related to this topic is greatly involved and henceforth not discussed further in this review.

In New Zealand, the EEM provides unit value of travel time disaggregated by trip purpose (e.g. work travel purpose, commuting to/from work, all other non-work travel purposes), vehicle type (car, motorcycle, light/medium/heavy commercial vehicle etc.), and passenger type (drivers, pedestrian, cyclist, bus passengers etc.).

The EEM also includes travel time values combining passenger and commercial (including freight) occupants and vehicle types for standard traffic compositions and different road types. In addition, additional values for traffic congestions have also been provided.

Table 1, Table 2 and Table 3 in Appendix A of this report reproduces the base values of travel times from NZTA's EEM vol 1 in Appendix A4 (page A4-2 and Page A4-3) for the above mentioned.

2.1.2 History and Basis of Travel Time in New Zealand

In New Zealand, the basis of the unit travel time historically goes back to 1971 when Read (1971) recommended value of travel time savings (VTTS) following a review of British and Australian practice for National Roads Board. Cox (1983) provided the next comprehensive review of the methodology and practice of VTTS, again based on international research. The working travel time values were estimated as the gross hourly wage rate plus any employment-related on costs borne by the employer.

In 1990/1991 Transit New Zealand incorporated revised VTTS based on review of Dr. Miller's analysis, the UK Value of Time (VOT) project, and a summary of experience in Australia by Hensher (1989).

The base VTTS for car drivers was based on 40% of the average wage rate in New Zealand. This was similar to values recommended by Hensher (1989) for use in Australia (36% for private car driver and 61% for company car driver) and by MVA et al. (1987) in the UK (46%). The recommended VTTS for seated bus passengers was 25% of the wage rate. The non-work travel time was determined using the Willingness to Pay (WTP) for non-work time savings.

(Reproduced as a summary from Booz Allen & Hamilton, 1997)

Booz Allen & Hamilton (2001) undertook an extensive work to establish unit values of time by trip purpose, degree of traffic congestion and uncertainty of travel time and make recommendation on changes to the VTTS used in Project Evaluation Manual as of 1991.

The current VTTS used in the EEM is based on resource value that is referred (Transfund Research Report No.93 1997) as *the amount of money that society is willing to "save" a unit of travel time.*

Table 2-1 includes different methods used for deriving monetary values of travel time values. (PIARC, 2004). Different methods are used to determine the travel time costs word wide. The following bullet points should be read in conjunction with Table 2-1.

- Resource costs are net of transfer payments such as taxes, duties and subsidies and reflect the cost to the nation. (STM/BCHF, 1997)
- Market price if the amount of money that people are willing to pay.
- Opportunity costs the value of resources in their best alternative use. For example, the opportunity cost of 'free' government owned land used for a project is the price at which that land could be sold in its existing state. (RTA, Economic Analysis Manual, 1999)
- Willingness to pay (WTP) is the value that consumers are willing to pay for a good or service that has no established market price. (RTA, Economic Analysis Manual, 1999)
- Revealed preference (RP) relates to 'actual choice' of the consumer. For example, with regards to travel time survey, the actual series of trips is presented in which the actual choice of respondents is recorded. Contrarily, a stated preference (SP) survey presents a series of hypothetical trips and their route choice if recorded.

Table 2-1: Methods used for deriving monetary values of travel time values, (PIARC, 2004)

Country	Travel Time (Business)	Travel Time (Non-business)
Australia	Resource	WTP
Canada	Salaries	Salaries
Czech Republic	Resource	Resource
Denmark	Market	
France	Market	RP
Germany	Resource	WTP
Hungary	Resource/ WTP	Resource/ WTP
Japan	Wage Rate	Wage Rate
Mexico	Market/WTP	WTP/Market
New Zealand	Resource	WTP
Norway	Resource	WTP
South Africa	WTP	WTP
Sweden	Alternative cost /WTP	WTP
UK	Market	WTP
USA	Opportunity	WTP

(Resource: Resource Costs; Market: Market Price, WTP: Willingness to Pay; Opportunity: Opportunity Costs; RP: Revealed preference)

2.2 New Zealand and International experience on forecasting of travel time benefits

As part of this research, a review of New Zealand and overseas experience on forecasting of travel time benefits and those realised on various projects has been carried out that is discussed in the following sections.

2.2.1 New Zealand Experience

Little or virtually no available research has been found for New Zealand that compared the travel time savings estimated during the economic appraisal of the project (pre-construction stage) against those realised (post construction). A contact with New Zealand Transport Agency (NZTA) was made with regards to available research data or any examples of projects that analysed forecasted benefits of transport investment projects to those realised. The researcher was unsuccessful in finding any relevant studies or projects either through NZTA or through external sources. However, the researcher examined a report on the Paremata-Plimmerton Upgrade project by Hyder Consulting Ltd (Hyder, 2008). This scheme was implemented in 2005 with improvements made to existing SH1 between south of Paremata roundabout to immediately north of the Plimmerton roundabout, including operation of High Occupancy Vehicle (HOV) lanes/T2 lanes in the peak times.

The independent review by Hyder Consulting Ltd (2008) only included the analysis of operational, social and environmental, safety and efficiency effects post completion of the project including consultation with the local residents and key stakeholders on these issues. The report did not present or has not analysed how the actual performance and the benefits of the project compared between pre-construction and post construction, as it was not part of the review objectives. The review report analysed the delays at the intersections and the side roads as part of the 2006 survey analysis following the completion of the project. However, they were the actual figures of post completion of the project and did not relate to how it compared with the pre-construction scenario. It should be noted that the review report also comments "No specific traffic surveys have been undertaken as part of this current 2007/2008 review, but observations and survey responses have indicated some concerns that delays on the main highway have increased further at weekends and during the evening peak southbound at the Paremata roundabout". In light of the above discussions, it is inconclusive if there were any actual travel time benefits or disbenefits for the project.

It is acknowledged that an independent review of the Wellington Inner City Bypass project (WICB) in the Wellington City, New Zealand is currently underway that aims to compare the forecasted performance and benefits of the project with post completion evaluation (before and after studies). However, the study is currently under progress due to which any further examples could not be included as part of this review task.

Although a before and after study programme that compares economic appraisal of the project (pre-construction stage) against those realised (post construction) does not exist/ or is not common in New Zealand. However, it should be noted that a similar programme exists in terms of safety monitoring by NZTA. A very comprehensive study of safety projects and their success is closely monitored by NZTA under the Safety monitoring programme. To support this, a national crash data base, Crash Analysis System (CAS) is maintained by NZTA that holds all the details related to crashes occurring on New Zealand roads. (Refer to http://www.landtransport.govt.nz/research/cas/index.html)

It is also acknowledged that a study comparing the pre and post construction of safety environment (in terms of crash reduction) including the predicted crash savings with the actual crash savings related to safety improvement projects (mainly rural road realignment) was carried at University of Canterbury (Muirson 2006).

2.2.2 International Experience

In United Kingdom, the Highway Agency (HA) undertakes an evaluation to see how the anticipated benefits (pre-construction) compare with those realised through an ongoing process of evaluation called Post Opening Project Evaluation (POPE). The POPE evaluation is undertaken on both the programme of Major schemes or Targeted Programme of Improvement (TPI) Schemes and Local Network Management Schemes (LNMS). TPI schemes are greater than £5 million in capital costs such as bypasses, large junction improvements, motorway widening etc. and LNMS are schemes less than £5 million in capital costs and managed on area by area basis. Whilst the TPI Scheme POPE is undertaken at one year and five year after opening the LNMS POPE is undertaken only after one year after opening.

The POPE process involves comparison of forecasts against realised/observed benefits related to traffic (e.g. traffic volumes, travel time etc), safety (crash reduction), accessibility, environment etc. This includes cost estimates and consultation with RCA and statutory consultees. The process does not include detailed assessment using traffic models but rather involves a transparent comparison of the observed vs. forecasted data.

On behalf of HA, WS Atkins (July 2007) prepared a POPE Meta report under the HA program of performance monitoring. The report examined around 40 completed schemes, 20 for TPI Schemes and 20 for the LNMS. The report findings were:

- Of the 14 (bypass schemes) of the 20 TPI Schemes examined, seven (50%) had out turn traffic flows consistent with the predicted flows; two (14%) had a total flow less than the forecast and about five (36%) had outturn flows greater than forecasted flows.
- Of the remaining six (online improvements other than bypasses) of the 20 TPI Schemes, three (50%) had outturn flows consistent with the predicted flows; three (50%) had outturn flows 30% higher than forecasted.
- Of the 20 TPI Schemes the outturn economy benefits (time savings and vehicle operating cost savings) for either (53%) were consistent with predicted values, four (27%) were better and three (20%) were lower.
- For all the 20 LNMS analysed, the outturn economy was 8.5% lower than predicted though it should be noted that the safety benefits were 30% higher than predicted. Overall the aggregate BCR for 20LNMS was lower (7.1) than predicted (8.2).

Source: Atkins (July 2007)

In addition to above review, the individual POPE reports were examined to gain an insight into the changes between the forecasted link transit time benefits and post construction transit time benefits situations. As there were many projects available online, only randomly selected TPI schemes were examined and summarised for the differences in the forecasted travel time benefits to those realised. Table 2-2 and Table 2-3 include differences in travel time benefit forecasts for one year POPE and five year POPE.

Table 2-2: Summary of One Year After Study - POPE for TPI Schemes

Project Name	Project Type	Forecasted Link Transit Time Benefits (Pre Construction) in Millions (£)	Actual Link Transit Time Benefits (Post Construction) in Millions (£)	Difference (%)
A5 Nescliffe Bypass	*Bypass*	*8.41*	*12.24*	*46%*
A6 Clapham Bypass	*Bypass*	*27.6*	*30.95*	*12%*
A6 Great Glen Bypass	*Bypass*	*10.40*	*12.50*	*20%*
A6 Rushden & Higham Ferrers Bypass	*Bypass*	*31.13*	*16.76*	*-46%*
A34/M4 Chieveley Improvement	*At Junction 13 of the M4 motorway, north of Newbury, and has provided an underpass on the A34 to divert through-traffic from the congested roundabout. And provide, new access roads were built for the service area.*	*122.7*	*74.8*	*-39%*
A6 Great Glen Bypass	*Bypass*	*10.40*	*12.50*	*20%*
The A1 Stannington Grade-Separated Junction	*Grade separation. An underpass with slip roads to replace four at-grade Crossings to improve safety by removing right-turning movements across the A1 and integration of the east and west parts of Stannington village.*	*18.8*	*11.5*	*-44%*

Table 2-3: Summary of Five Year After Study - POPE for TPI Schemes

Project Name	Project Type	Forecasted Link Transit Time Benefits (Pre Construction) in Millions (£) – 30 Year analysis period	Actual Link Transit Time Benefits (Post Construction) in Millions (£) – 30 year analysis period	Difference (%)
A34 Newbury Bypass 'Five Years After' Evaluation (1998-2003)	*Bypass*	*365.4*	*583.5*	*60 %*

Atkins (2007) explain the reasons for variability of traffic flows and the associated economics benefits are due to:

- Incorrect traffic growth predictions that resulted in higher or lower forecasts compared with the outturn flows
- Other completed schemes that were not included in the Do minimum scenario during the appraisal process that affects outturn traffic levels.
- Limited geographic scope of the traffic models used for the appraisal process that does not account for long distance strategic re-routing.
- Land use changes and development

2.3 Use of traffic models in forecasting travel time savings

Welch and Williams (1997) comment that "where monetary quantification of time savings is undertaken in transport studies, whether for highway, public transport, or traffic management schemes, the estimates of benefit are usually presented as if they are endowed with considerable accuracy; the major sources of error are considered to be ability of traffic models to furnish the changes in demand and travel accompanying a project."

Currently, various traffic modelling packages are used for estimating travel time and various other economic impacts due to transport improvement schemes. These traffic models range from a Microscopic traffic models (vehicles or road users are modelled individually) to Macroscopic (vehicles or road users are modelled collectively as flows or platoons). Depending on the model input capabilities and level of detail, a certain level of vehicle disaggregation is incorporated and resulting outputs are used to determine transport benefits. Most of the current traffic models convert each vehicle type in to an equivalent number of Passenger Car Units (PCU's). A unit cost data is applied to these PCU's to obtain travel time savings, vehicle operating costs etc.

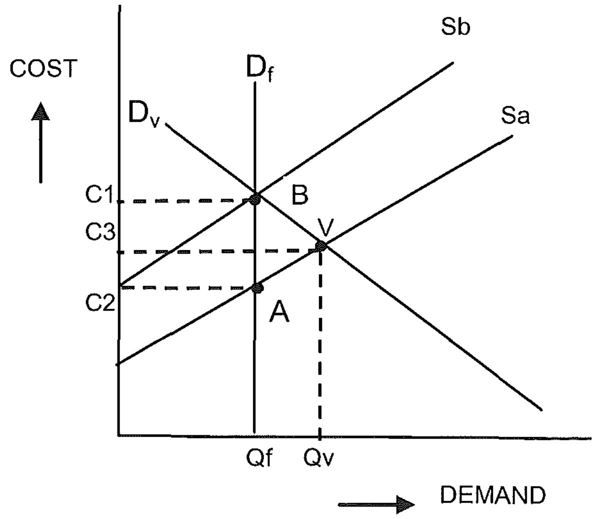
Fisk and Dunn (1986) undertook a research project to identify operational urban road traffic models which have the potential for predicting economic impacts of road improvements. In one of their conclusions they state that *"if the model is a good representation of the real world system, its application could result in significant benefits to society by reducing the generalised costs of travel. If the model is not reliable the predicted benefits may not be realised and society will be subsidizing the implementation of a model which may ultimately make road users worse off".*

The most important part of the traffic model is its ability to model what happens in reality i.e. to accurately represent the road user behaviour. There is a large complexity of travel behavioural responses to network conditions and the changing time scales of response. In addition, there are many important modelling and evaluation issues which can significantly affect the results of traffic models. These issues are briefly discussed and included below:

2.3.1 Variable travel demand vs. fixed travel demand

Mackie and Bonsall (1989) state that fixed travel demand technique corresponds to changes on the road network resulting in a change on the route i.e. trip reassignment on the transport network tend to ignore the travel behavioural responses to travel mode, trip distributions, travel timings etc. They illustrated the effect of the assuming a fixed trip matrix using Figure 2-1 in cases where there is congestion on network. The following discussion has been reproduced from STM/BCHF(1997) that was derived from Mackie and Bonsall (1989) and illustrated using Figure 2-1

Figure 2-1: Demand Cost relationship – Fixed vs. Variable demand matrices.



Source: Mackie and Bonsall (1989)

The demand curves, D_v represent the variable demand and D_f represents a fixed demand and is a vertical line. The supply (S) versus costs (C) curves is shown as S_b and S_a for before and after. In the before situation, point b is the intersection of the supply and demand curved, with demand Q_f and cost C_1. After the project situation (increase in supply) the fixed demand assumption would indicate cost C_2 and demand Q_f (same as demand is fixed), while a variable demand would indicate cost C_3 and demand Q_v. The variable demand C_3 is greater than C_2 (fixed demand) but less than C_1 (before situation).

The quantified benefit under the fixed demand assumption is the area under C_1BAC_2. However, the 'true' benefit is C_1BVC_3. This is illustrated using the following equations:

Benefits assuming fixed demand = Δ C *Q_f ....(1)

Benefits assuming variable demand = Δ C *Q_f + 1/2 * Δ C * (Q_v - Q_f) ....(2)

Mackie and Bonsall, further explain the limiting cases of this theory in their research. In summary, their research concludes that ignoring demand response when appraising the transport projects could lead to over-estimation (or under estimation of benefits in some cases).

Please note that, in New Zealand, the variable demand matrices or Variable Trip Matrix (VTM) approach is used for complex and large scale network improvement projects. For the use of VTM approach, NZTA's EEM Vol 1 App A11 contains guidance on the evaluation of congested networks and induced traffic.

2.3.2 Issues associated with the use of resource costs in transport models

Travellers make their route choice and travel modes based on 'their perception' of costs. However, most of the travel demands models use the resource costs when modelling transport demand even though perceived costs is not always the same as the resource costs.

Fisk and Dunn (1992) state that travel time may not be the only component of user perceived cost and vehicle operating costs are likely to be a factor but usually perceived to be below the resource cost. They emphasise the necessity of obtaining a single impedance measure which reflects user perceived cost. They also comment that the use of travel time as a single measure could lead the traffic model predictions incompatible with empirical data collected after an improvement has been implemented on the network.

Fisk (1988) state that *"for a range of alternatives where travel time is positively linearly correlated with operating costs this hypothesis is reasonably compatible with the assumptions in many demand models where travel time is the assumed disincentive to travel. However when a reduction in travel time can lead to an increase in operating costs the resulting economic analysis can lead to the apparently illogical conclusion that improved facilities lead to user disbenefit".*

Fisk suggests these situations could be improved by replacing travel time in the assignment model by perceived costs which are determined by a combination of time and vehicle operating cost and including perceived costs in the economic evaluation.

Fisk (1988) recommends the use of perceived costs in traffic forecasting where resource and perceived costs differ. Fisk also recommends in these situations both the perceived and resource costs are included in the evaluation and the benefits are calculated as follows.

$$B = \sum_{ijm} 1/2\,(T_{ijm} + T'_{ijm})\,(p_{ijm} - p'_{ijm}) + T_{ijm}\,(c_{ijm} - p_{ijm}) - T'_{ijm}\,(c'_{ijm} - p'_{ijm})$$

Where:

B = Benefits

T_{ijm} and T'_{ijm} are assumed as existing and new trips from i to j by mode m respectively and c_{ijm} and c'_{ijm} are the corresponding costs.

p_{ijm} and p'_{ijm} represent the perceived costs before and after the improvement

Source: Lane et al. (1971)

2.3.3 Implications of Constant travel time budget theory

Wee, Rietvald & Meurs (2002) state *that "the theme (of constant travel time budget) is important because constancy of travel time implies that neither long run developments such as technological change and economic growth, nor transportation policies have a notable impact on transport volumes. Changes in the composition and spatial patterns may of course be substantial, but the total volumes would remain unaltered. In particular the constancy of travel time would imply that development of faster modes would lead to longer travel distances".*

Wee, Rietvald & Meurs (2002) conducted a research to establish developments in 'time use' in Netherlands to understand why the research carried out during the past decades indicated an increase in average travel time for the Dutch population. They investigated different data sets of national travel time surveys and concluded that they agreed that average travel times have increased in the past decade. Further, they listed possible causes of an increase in travel time due to various reasons; however, they acknowledged that further research is needed to find out if they really play a role in the travel time budgets. The following discussion has been reproduced from Wee, Rietvald & Meurs (2002) which lists the possible causes of an increase in average travel time.

(a) A possible increase in utility of travel. The possible reasons why this utility might have increased are presented below.

- Spatial trends.
- Specialisation of labour market and of the skills of employers
- Segmentation in the housing market.
- A diversification of leisure activities.
- Travel for fun.
- Other economic developments.

(b) The changing costs of travel. Some possible reasons why this utility might have increased are listed below.

- The increase in the share of car kilometres of motorways.
- A reduction in the improvements of the road network.
- The role of bicycle.
- The increased level of comfort of cars.
- Improved road safety.
- Increased possibilities to combine travel with other activities.

(c) Changes in the population. The possible reason why changes in the population have led to increase in average travel times is listed below.

- More people combining different tasks.
- A decrease in household size.

DeCorla-Souza (1999) comments that "related to issues of induced travel is the constant travel time budget theory. Environmental advocated suggest that there is a lack of any real time savings when roads are improved because travellers driver farther to take advantage of improved speeds, thus not really saving time. There is truth to the argument that travellers tend to travel longer distances or make more trips when travel speeds are improved, thus consuming any travel time savings". Decorla-Souza (1999) supports his statement by quoting the (FHWA (1997) research outcome that the travel times for commute trips have stayed fairly constant at about 20 min over the past three decades, even though highway travel speeds improved considerably as a result of freeway building.

However, DeCorla-Souza (1999) claims that the above issue can be addressed if four-step traffic models are run correctly. DeCorla-Souza explains that this could be achieved when four step models are run with highway network impedances that reflect road systems. The travel time impedances make the trip distribution model to send the trips to farther destinations as a result of travel time improvements. On the other hand, the mode split model shifts trips to solo driver auto mode from public transport or carpooling. For those trips that are shifted to more distant destinations, the benefits might not be the 'savings in time' because of the possibility that amount of time used in travel for that trip may not change. However, DeCorla-Souza states that even when the trip travel time stays the same, the trip maker can benefit and these benefits could be captured by consumer surplus approach instead of conventional link based system analysis, which uses reduction in vehicle-hours as a measure of benefit.

DeCorla-Souza (1999) illustrates the above concept by an illustrative example which has been reproduced and included below.

Illustration:

Assume that there are zones in a metropolitan area. Zone1 is residential, and Zones 2 and 3 are commercial. As shown in Table below, initial travel times from Zones 2 and 3 are, respectively, 20 min and 30 min. Initially, all 200 shopping trips from Zone 1 go to Zone 2. Now assume that roadway improvement reduce travel times from Zone 1– by 5 min to Zone 2 and by 10 min to Zone 3. As a result of the reduced travel times, all 200 shopping trips previously going to trip 2 are diverted to Zone 3, so that the diverted travellers continue to take same amount of time (i.e. 20 min) to get to their new destination as they did to get to there previous destination – that is, they do nor Save time compare with their previous trips to Zone 2.

As Table 2-4 shows, if this 200 trips from Zone 1 were the only trips on the network, total vehicle hours travelled (VHT) would be the same before after the improvements, resulting in no VHT reduction. On the other hand, the diverted travellers do get mobility benefits calculate using consumer surplus theory. Lack of reduction in VHT does not mean that there are no mobility benefits.

Table 2-4: Estimation of benefits when no time is "saved"

	Zone 1 to Zone 2	Zone 1 to Zone 3	Total
Travel time before improvement (min.)	20	30	
Travel time after improvement (min.)	15	20	
Number of travellers before improvement	200	0	200
Number of trips after improvement	0	200	200
Vehicle hours of travel:			
Before improvement	66.7	0.0	66.7
After improvement	0.0	66.7	66.7
Change			0.0
Mobility benefits using consumer surplus approach (hours)	0	½*10*200* 1/60 = 16.7	16.7

2.3.4 Limitations of link based project analysis

For transport improvements project, many evaluations, if not all, use link-based analysis for project economic appraisal. The link based analysis takes in to account only portion of total trip length rather than from full trip length from origin and destination. DeCorla-Souza (1999) comments that it is difficult to get an understanding of the overall benefits to individual uses of the transportation system if we look at benefits in piecemeal fashion, as is done in link based analysis.

Axhausen et al. (2006) state that a link based cost benefit analysis is clearly inappropriate if the value of travel time savings of the link users depend on their respective distance. They emphasise the need to accelerate the ongoing change of origin-destination specific analysis in those countries that still employ the link based approaches.

DeCorla-Souza (1999) point out another issues of link based analysis that this approach may overstate the benefits of highway improvement projects, if links that provide access to the improved link are taken into account. DeCorla-Souza illustrates the above concept by an illustrative example which has been reproduced and included below

Illustration:

A link-based corridor analysis was conducted for the proposed new Route 710 freeway in the Los Angeles area. The project involved closing the 6.9m "gap" between the I-710 and I-210 freeways. The Build alternative involved a new freeway facility comprised of three new general-purpose lanes in each direction (for a total of six lanes), supplemented by two new high-occupancy vehicles (HOV) lanes. The analysis was conducted at three levels: corridor, study-area and regionwide. The corridor analysis included the proposed new freeway and parallel arterial facilities within 1.61km on either side. The study-area included surrounding freeways and arterials within about 8 km on either side.

Year 2010 travel-demand estimates were produced using four-step travel-demand forecasting models. Table 2-5 presents the ADT estimates in the corridor across a centrally located screenline, for the Route 710 freeway and, in aggregate, for parallel arterials. Table 2-5 also shows VKT in aggregate for freeways and other arterials for the study-area and for the entire region. The VKT estimates show that the Build alternative attracts to the study area a significant amount of traffic diverted from the surrounding region. The traffic diversions *to* the window area in the Build alternative cause increased congestion on freeway links used to access the new Route 710 link.

Table 2-5 next presents the estimated annual benefits from three perspectives: corridor, study-area "window", and regionwide. Note that travel time savings are much higher at the corridor level of analysis ($178.2 M [million]) than at the study-area and regionwide levels ($77.7 M and $92.9 M respectively). Travel time benefits are highest at the corridor level because only the new link and parallel north-south arterials are accounted for, while routes accessing these facilities are ignored. Benefits are reduced at the study-area level because of the relatively heavier congestion experienced on the surrounding freeways of the State Route system and on perpendicular east-west arterials, which are used to access the segment of Route 710. Disbenefits on these links are subtracted from benefits that accrue on north-south corridor links. Benefits increase at the regionwide level (relative to the study area level) because at the regionwide level, benefits to the undiverted travellers due to congestion reductions outside the windowed area are accounted for.

Table 2-5 next presents "Other Benefits", which include change in cost other than travel time costs (i.e., costs for vehicle operation, accidents, air pollution, noise, and parking). Because these costs are strongly correlated with VKT, they increase at the corridor level, causing net benefits of $19 M. However, net benefits of $24.7 M are estimated at the regionwide level, as reductions in VKT in other parts of the region are accounted for, along with an overall shift in VKT from arterials to freeways that have lower accidents costs.

As Table 2-5 shows, total estimated benefits are highest at the corridor level ($159.2 M) reducing to $84.2 M at the study area level, but increasing again to $117.6 M at the regionwide level. The estimates of study area and regionwide benefits are far below those estimated at the corridor level.

Table 2-5: Route 710 corridor: 2010 Travel Demand, Benefits and Costs

		No Build	Build
Corridor ADT:	Freeway, mixed flow lanes	0	162,000
	Freeway, HOV	0	16,000
	Parallel arterials	87,000	56,000
	Total	**87,000**	**234,000**
Study Area VKT (Million):	Freeways	12.56	13.45
	Arterials	5.83	5.34
	Total	**18.40**	**18.79**
Region wide VKT (Million):	Freeways	244.39	245.37
	Arterials	194.65	193.89
	Total	**439.04**	**439.26**
Annualised Benefits & costs ($M)			
Corridor:	Travel Time		178.2
	Other benefits		-19.0
	Total Benefits		159.2
Study Area VKT:	Travel Time		77.7
	Other benefits		6.5
	Total Benefits		84.2
Region wide VKT (Million):	Travel Time		92.9
	Other benefits		24.7
	Total Benefits		117.6

Source: DeCorla-Souza (1999)

2.4 Implications of the study

The reasons for the discrepancies in the forecasted and outturn benefits in Section 2.2.2 are fair and reasonable given there are wider impacts due to the provision of new transport infrastructure and there are many externalities that influence the driver behaviour, route choice and mode of transport. However, it should be noted that the differences (which were under or over) between the forecasted traffic flows and the observed traffic flows due to incorrect traffic growth might not be fully true. The POPE assessment looks at initial impact of the schemes. Any sudden increase or decrease in traffic growth is not sustainable for the full 30-year analysis period of the schemes. It normally takes few years (more than one to three years) for longer-term trends to establish.

There are various factors which influence a reasonable estimate of travel time savings. The factors range from use of inappropriate modelling techniques when using travel demands models e.g. fixed vs. variable demand matrices to link based analysis which may over estimate the system benefits. The factors also include perceived value of travel time for the consumers to the actual value of time used in the analysis. Lack of overall savings in travel time does not imply that there no benefits. The use of trip based analysis and appropriate network impedances could address the issues related to constant travel time budget theory and link based analysis.

In the context of New Zealand, a process such as POPE would be extremely beneficial which would make the claims of efficient investment of rate payer's money more transparent for provision of transport infrastructure. By monitoring the performance of the transport infrastructure schemes it not only highlights the accuracy issues associated with the scheme appraisals but also help to identify any deficiencies in the evaluation process and provide an opportunity for potential improvements.

An example report structure of the POPE process is included in Appendix A for information purposes.

3 Methodology

3.1 Introduction

This section describes the methodology and case study sites selected for this study. This includes selected study site and the procedure adopted to compare the pre-construction and the post construction analysis.

3.2 Study Sites

The identified study sites as agreed in the development of this research study are listed below.

1) Study Site 1: Kaitoke to Te Marua Realignment, 2002

2) Study Site 2: Mungavin Intersection Upgrade (Mungavin Roundabout), 1987

3) Study Site 3: Wellington Inner City Bypass Project, 2006

4) Study Site 4: Paremata to Plimmerton Upgrade, 2006

The selection of the study sites was based on the following simple reasons:

- Availability and access to pre-construction analysis e.g. Scheme Assessment reports, pre-construction data like traffic volume surveys, journey time surveys used in the economic analysis and access to any traffic models used for the economic appraisal.
- Advantage of local knowledge and familiarity with the sites and
- Location convenience to carry out the study

It should be noted the even though the Mungavin intersection upgrade was included in analysis to investigate the effects of projects which are well established and the consequences of carrying out post-construction review after a significant time lag.

3.3 Procedure

In general, the procedure involves reviewing the pre-construction economic appraisal analysis by reviewing the Scheme Assessment Report (SAR) and the associated tools and traffic data used to carry out the economic appraisal. Followed by this, the post construction analysis process involves collecting the post construction traffic data (e.g. Journey time surveys, speed surveys etc.) to be consistent with the pre-construction appraisal methodology and then using the collected survey data for post-construction appraisal.

The procedure involves the following tasks:

- Review the respective SAR's and the data used during the project economic appraisal (pre-construction).
- Identify the key economic appraisal data and tools used to carry out the pre-construction appraisal
- Undertake post-construction traffic surveys such that a reasonable level of comparison can be made.
- Analyse post-construction traffic surveys and determine post-construction travel time benefits to compare with the pre-construction appraisal
- Where SATURN traffic models are used, the procedure includes:

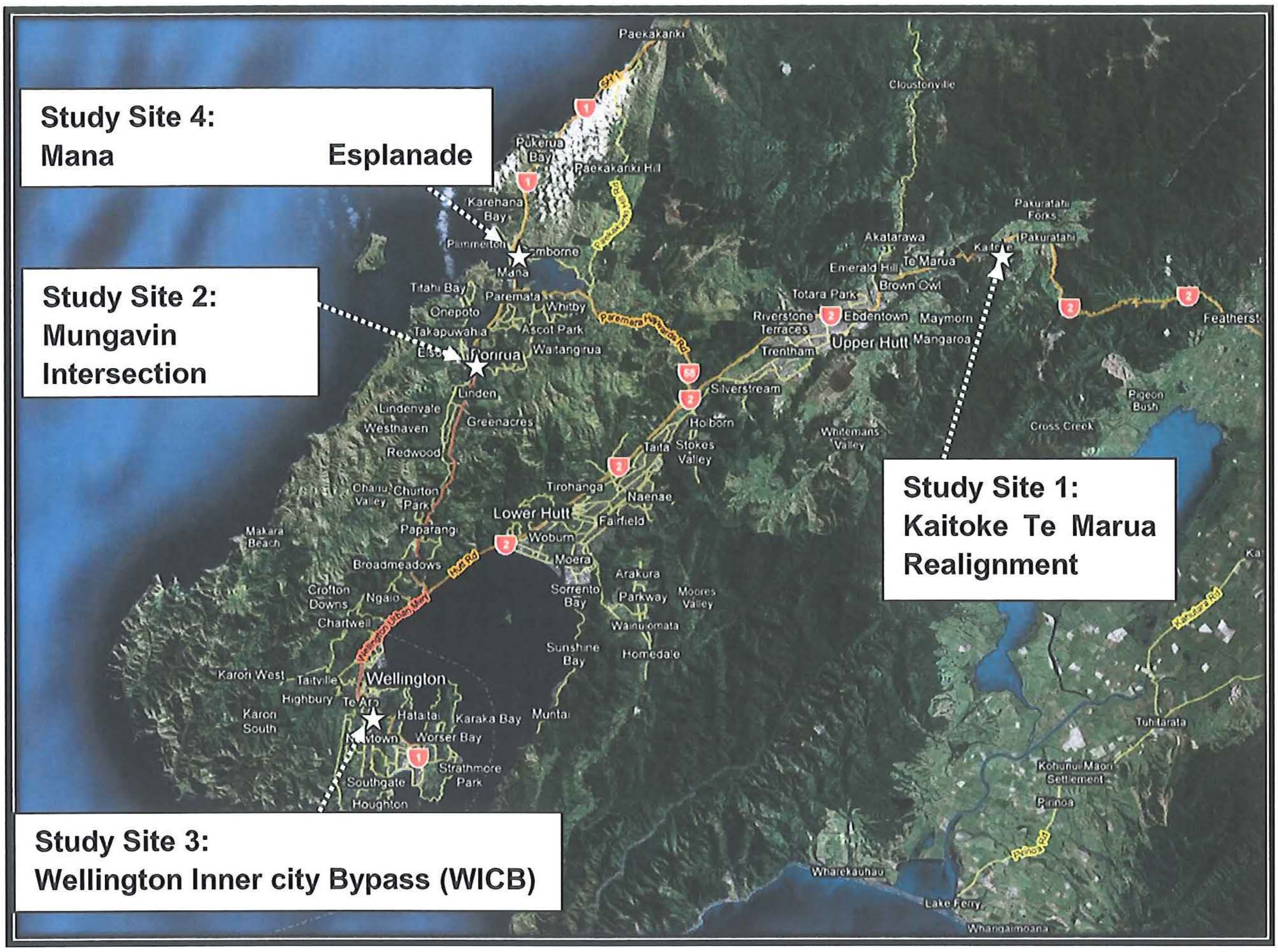
    - Model the do minimum scenario (pre-construction scenario) for the identified schemes using the latest calibrated SATURN model. This process will involve removing the respective individual scheme(s) from the SATURN model and then running the model. This process will also help to gauge the impacts of the 'without scheme' scenario at the network level for the current conditions i.e. this process will determine the performance of the network 'without the identified scheme' but will include the other network changes both in infrastructure and traffic growth that have already occurred.
    - Assess the impact of the 'without and with' scheme scenarios on the existing network, using the SATURN model outputs.
    - Where possible, compare the post construction travel time, traffic volumes, average speeds etc. with SATURN calculated travel times, speeds and traffic volumes.
    - Followed by the modelling process, determine the travel time benefits for the above discussed 'without' and 'with' scheme modelling scenario's by using the latest calibrated SATURN model outputs.

Figure 3-1 includes location of study sites and Table 3-1 includes a summary of the pre-construction vs. post-construction economic appraisal tools and traffic data.

Table 3-1: Economic appraisal tools and traffic used in the analysis

Study Site	Pre-construction	Post-Construction	Comments / Notes
Study Site # 1: Kaitoke to Te Marua Realignment.	Tranfsund Project Economic Evaluation procedures. (Now NZTA's EEM vol 1), travel time speed predictions.	Recorded travel time speed surveys and appraisal methodology consistent with the pre-construction analysis.	
Study Site # 2: Mungavin Intersection Upgrade.	SIMSET 2 and ROUNDCAP for signalised intersection and Roundabout option traffic delays. Geometric delays using graphical/tabular methods of Austroads	Calibrated Transmission Gully SATURN traffic model.	Calibrated SATURN model used to understand the network wide effects of this significant intersection on SH1.
Study Site # 3: Wellington Inner City Bypass (WICB) Project	Calibrated WICB SATURN traffic model (2002) and Transfund Project Economic Evaluation procedures. (Now NZTA's EEM vol 1),	WICB SATURN traffic model updated and calibrated to year 2006 appraisal methodology consistent with the pre-construction analysis. Comparison of pre-construction and post-construction journey time surveys and traffic volumes on selected links on the network.	Please note at the time of this analysis the proposed WICB SATURN update and calibration to 2006 year census data was still underway. In the absence of the model the 2002 calibrated SATURN model was updated to network changes (2002 – 2006) and WTSM regional model matrices were applied to SATURN model
Study Site # 4: Paremata to Plimmerton	AIMSUN model to determine intersection delays, Journey time surveys, side road delays, High Occupancy vehicle (HOV) lane usage forecast?	Journey time surveys for normal and HOV lanes, side road delay surveys.	Author unable to get access to SAR and associated economic appraisal tools.

Figure 3-1: Location of Study Sites



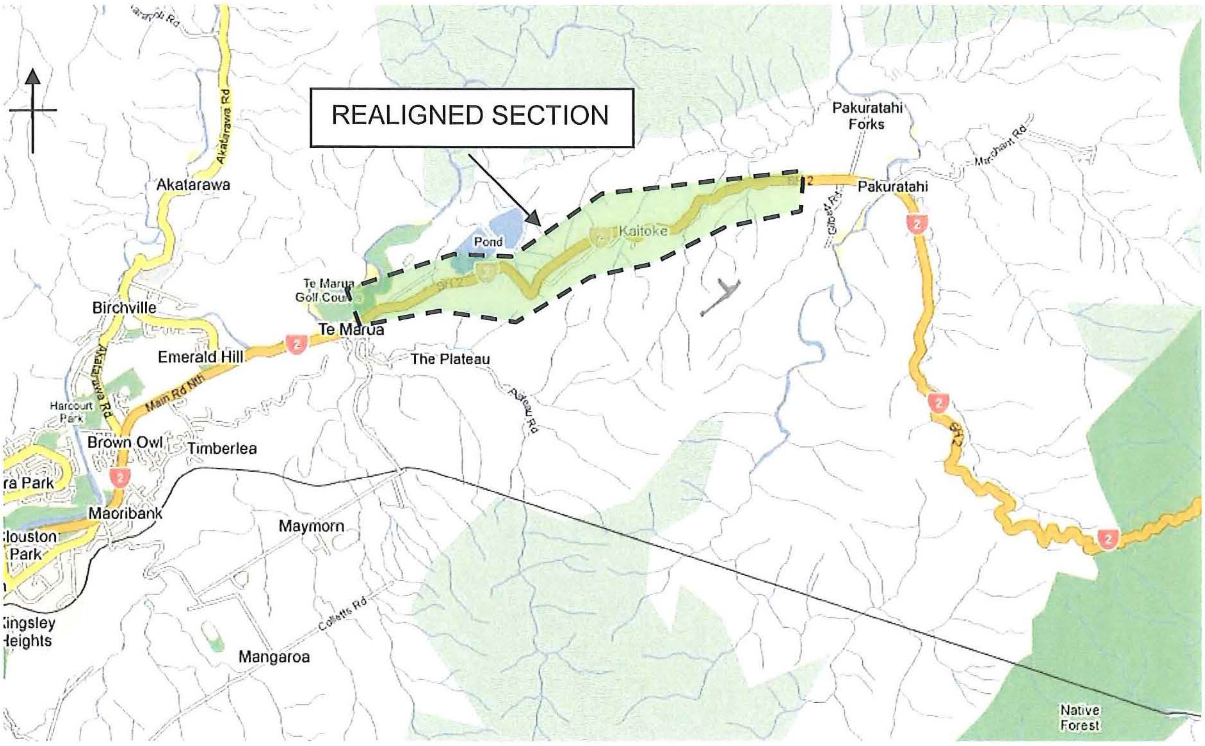
4 Analysis

4.1 Study Site 1 – Kaitoke to Te Marua Realignment

4.1.1 Pre-construction Analysis

The study site is located on Kaitoke Hill, State Highway 2 (SH2), between Upper Hutt and the Rimutaka Hill, and is approximately 40 km from Wellington. SH2 is the only direct route between Wellington and Wairarapa; therefore is a key regional link and part of the national strategic highway network. Refer Figure 4-1 for location plan

Figure 4-1: Location of Study Site 1, Kaitoke to Te Marua Realignment



Due to the significant improvements that had been made to SH2 out of Wellington, Kaitoke Hill and Rimutaka Hill were seen as the main sections of highway that required an upgrade to improve this regional link. An extract from the pre-construction SAR Opus (1998) to describe the site that existed before the realignment and the associated problems is given below.

"The study site is approximately 5.5 km in length which climbs from a level of 225 m at Kaitoke to 280 m at the summit before descending to a level of 100 m at Te Marua. The alignment consists of steep grades of up to approximately 9% and an inconsistent

horizontal alignment with some curve radii not much greater than 30 m. The main problems with the existing highway are as follows:

- *Inconsistent highway alignment on steep upgrades*
- *Narrow roadway, outside of passing lane sections, with generally minimum or no shoulders*
- *A large number of private accesses that connect directly on to the highway. Many of these are at locations where visibility is restricted*
- *A lack of"pull off" area clear of the traffic lanes for turning traffic into and out of properties also restricting where the school bus can stop.*

These problems resulted in a high accident rate on this section of SH2, which is approximately twice the national average. For 5 year period between 1993 and 1997, 82 reported crashes were recorded with 33 injury and 49 non-injury accidents........."

The SAR looked at various options and reported on the corresponding BCR's. A final update of the economics analysis was carried out in 2002 and the BCR's were reported. The summary of the calculated benefits and costs is included in Table 4-1 below. The analysis was carried out in accordance with Transfund's Project Evaluation Manual. (Now NZTA's EEM vol 1). The analysis assumed time zero as 1 July 2002, with construction spread over a two year period, and the benefits coming on stream from year 2005. Traffic growth rate of 3.6% with time zero AADT at 5044 veh was included in the analysis. In addition, a 25 year analysis period at a 10% discount rate was used in the analysis.

Table 4-1: BCR Summary of Te Marua Realignment (2002)

	Do Minimum	**Option**	**Benefits / Costs**	**% of total benefits**
Travel Time Costs (TTC)	$55,281,108	$43,694,201	$11,586,907	**28.7%**
Vehicle Operating Costs (VOC)	$49,933,890	$44,319,947	$5,613,943	13.9%
Accident Costs (due to realignment)	36,426,359	$17,227,128	$19,199,231	47.5%
Carbon Dioxide Costs	$2,166,161	$2,028,513	$137,648	0.3%
Passing Lane Benefits	-	$1,578,949	$1,578,949	**3.9%**
Acc Save - Passing Lane	-	$1,908,359	$1,908,359	4.7%
Accident Disruption	-	$387,530	$387,530	1%
Total Benefits (PV)		$40,412,567		
Capital Costs	-	$12,360,548	$12,360,548	
Maintenance Costs	$1,118,410	$293,793	- $824,617	
Total Costs (PV)		**$11,535,931**		
BCR =		**3.5**		

(Please refer to NZTA's EEM for to understand the concepts of time zero, discount rates, present value (PV) etc)

It is evident from Table 4-1 that crash benefits constitute to approximately 50% of the total benefits and travel time benefits make up to 29% of overall benefits. In addition to the benefits from travel time, benefits for passing lane have also been claimed based on the assumption that the existing horizontal alignment (pre-construction) hampers obtaining the full benefits from existing passing lanes for up hill traffic on both sides of the summit.

The 2002 economic analysis was built using Lotus spreadsheets which had one worksheet per spreadsheet instead of the current Microsoft Excel worksheets that allows having numerous worksheets in a spreadsheet, allowing for a proper linkage between calculations carried out on each worksheet. The economic model did not contain all the calculations and therefore the calculations have been back calculated and compared with other calculations in the spreadsheets to understand the underlying input parameters to derive the respective values. For example, calculated travel time values have been manually entered to determine the travel time benefits without any commentary on how these values were determined using assumed/calculated travel speeds. However, overall the calculations seemed reasonable.

As discussed above, the calculated travel times used in the economic analysis and the back calculated travel speeds are summarised in Table 4-2 and Table 4-3. The travel times were calculated for each vehicle type.

Table 4-2: Summary of calculated Travel times used in Pre-construction analysis

Vehicle Classification	Do Minimum Calculated Travel Time (Seconds) (Project Length = 6100m)		Option Calculated Travel Time (Seconds) (Project Length = 5680m)	
	Southbound	Northbound	Southbound	Northbound
Car	**342.2**	**357.4**	**249.1**	**249.1**
LCV	**342.2**	**357.4**	**249.1**	**249.1**
MCV/HCV	**411.7**	**509.3**	**304.5**	**473.4**

Table 4-3: Summary of calculated Travel Speeds used in Pre-construction analysis

Vehicle Classification	Do Minimum Calculated Travel Speeds (km/hr) (Project Length = 6100m)		Option Calculated Travel Time (km/hr) (Project Length = 5680m)	
	Southbound	Northbound	Southbound	Northbound
Car	64	61	82	82
LCV	64	61	82	82
MCV/HCV	53	43	67	43

The other factors influencing the calculations of travel time benefits used in the pre-construction economic appraisal are the traffic composition of the total AADT. The traffic composition and their associated travel time costs used in the pre-construction economic analysis is included Table 4-4.

Table 4-4: Summary of traffic composition and travel time costs used in Pre-construction analysis

Vehicle Classification	Traffic Composition used in the pre-construction Economic Appraisal	Value of Time ($ / hr) (2001 values)
Car	77%	$17.45
LCV	9%	$22.71
MCV	5%	$23.36
HCV-I	4%	$32.86
HCV-II	5%	$42.36

As noted earlier, the pre-construction analysis included a small portion of passing lane benefits based on assumption that pre-construction horizontal alignment hampers obtaining the full benefits from existing passing lanes for up hill traffic on both sides of the summit. The calculated passing lane benefits included travel time, vehicle operating costs and driver frustration savings using the passing lane procedures calculation spreadsheet (Koorey, 1999) developed for Transfund New Zealand. It should be noted that the analysis assumed that currently (pre-construction) only 50% of total benefits of passing lane benefits were realised due to horizontal alignment constraints and that the realignment option would release the remaining 50% of passing lane benefits.

Also, it should be noted that the analysis did not separate the travel time and vehicle operating cost benefits. Table 4-5 includes pre-construction passing lane benefits and passing lane speeds used in the analysis.

Table 4-5: Summary of calculated Travel Speeds used in Pre-construction analysis

Passing Lane	Passing Lane (TTC & VOC Costs) - Undiscounted		Option mean Speed (km/hr)		Passing lane benefits Discounted ($) - Only 50% of calculated benefits
	Do Min	Option	Car	HCV	
Southbound	$151,599	$104,186	80	53	$633,800
Northbound	$237,797	$25,492	80	24	$933,950
TOTAL =					$1,567,750

It should be noted that the post construction analysis assumed a traffic growth rate of 3.6% and traffic volumes of 5044 at 2002.

4.1.2 Post-construction Analysis

Traffic speed surveys were carried out at Study Site #1, Kaitoke Te Marua Realignment on 3 Dec 2008 and 4 Dec 2008. The traffic surveys involved a combination of floating car surveys and the GPS tracking system i.e. a car fitted with GPS tracking system was used to follow cars (lights) and heavies (Truck & Trailer, Bus etc) in both northbound and southbound directions. The peak period surveys were carried out between 3:45pm to 6:15pm for PM peak, 6:30am to 9:00am for AM peak and 10:30am to 12:00pm for Inter Peak. Please note that these surveys results are based on a total sample range of 10 to 15 samples per vehicle by each direction.

The survey results are summarised in Table 4-6 below.

Table 4-6: Summary of observed Travel Speeds for Cars and Heavies

Time Period	Average CAR Speeds (Km/hr)		Average HCV Speed (Km/hr)	
	Southbound	Northbound	Southbound	Northbound
AM	94	87	76	68
IP	79	85	68	59
PM	86	87	81	63
Average Speed (Full day)	**86**	**86**	**75**	**63**

In addition to the traffic speeds, the latest traffic data (2001 to 2007) was obtained from Transit New Zealand (www.Transit.govt.nz) website for SH2 Rimutaka Telemetry Site (SH2/931/593) to determine the existing traffic composition at the site. It is essential that the a robust traffic composition figures based on either weighted average of historic traffic flows or the existing traffic composition is used to determine the economic benefits where the benefits are broken down by vehicle types. This is mainly due to the fact that travel time costs assigned to the heavies are significantly higher and over estimation of these vehicles could lead to over estimation of travel time and other associated benefits.

The 2001 to 2007 traffic data indicated a high proportion of cars compared to the rest of the vehicles at the site. The calculated traffic composition figures are included in Table 4-7.

Table 4-7: Summary of current traffic composition at the study site

Vehicle Classification	Current Traffic Composition at Rimutaka Telemetry Site
Car	92%
LCV	3%
MCV	3%
HCV-I	1%
HCV-II	1%

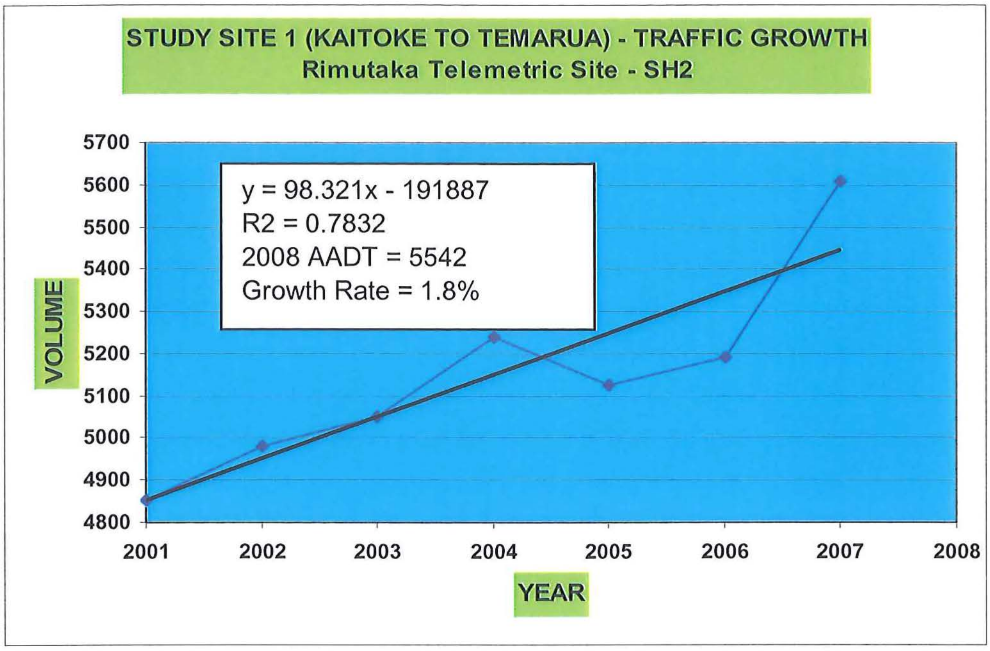
Though, the recorded speed surveys did not include a detailed break down of speeds to quantify the benefits of existing passing lanes, the speed surveys were closely examined (by matching the GPS co-ordinates with Google earth co-ordinates of speed survey data and locating the data points along passing lane section) and the section lengths related to passing lanes were separated to note the average speeds of cars and heavies in the vicinity of the northbound and southbound passing lanes. Table 4-8 includes a summary of observed travel speeds in the vicinity of passing lanes

Table 4-8: Summary of observed Travel Speeds in the vicinity of passing lanes

Passing Lane	Pre-construction Option mean Speed (km/hr)		Post-construction Option mean Speed (km/hr)	
	Car	HCV	Car	HCV
Southbound	80	53	90	80
Northbound	80	24	79	44

As part of the post-construction analysis, traffic growth rates based on the latest count data was determined. The historic traffic volumes at the Rimutaka Telemetry site indicated the 2008 traffic volumes would be approximately 5,540 vpd with a growth rate of 1.8%. This pre-construction analysis also predicted an AADT of 5044 vehicles for year 2002. The post-construction actual traffic data indicates AADT of 4980vpd. Figure 2-1 included post-construction traffic growth calculated at Kaitoke to Te Marua Realignment site.

Figure 4-2: Post-construction Traffic Growth, 2008



4.1.3 Results and Discussion

Comparison of Pre-construction and post-construction traffic data is included in Table 4-9 , Table 4-10 and Table 4-11 for travel speeds, traffic composition, speeds in the vicinity of passing lanes respectively.

Table 4-9: Comparison of Pre-construction assumed travel speeds and post construction travel speeds

Vehicle Classification	Pre-construction Travel Speeds (km/hr)		Post-construction Travel Speeds (km/hr)		Difference (km/hr)	
	S'bnd	N'bnd	S'bnd	N'bnd	S'bnd	N'bnd
Car	82	82	89	86	7	4
LCV	82	82	89	86	7	4
MCV	67	43	76	65	9	22
HCV-I	67	43	76	65	9	22
HCV-II	67	43	76	65	9	22

Table 4-10: Comparison of Pre-construction assumed travel speeds and post construction travel speeds

Vehicle Classification	Pre-construction Traffic Composition	Post construction Traffic Composition	Difference (%)
Car	77%	92%	15%
LCV	9%	3%	-6%
MCV	5%	3%	-2%
HCV-I	4%	1%	-3%
HCV-II	5%	1%	-4%

Table 4-11: Comparison of Pre-construction vs. Post-construction travel speeds of passing lanes

Passing Lanes	Pre-construction Option mean Speed (km/hr)		Pre-construction Differential speeds)	Post-construction Option mean Speed (km/hr)		Post-construction Differential speeds)
	Car	HCV		Car	HCV	
S'bnd	80	53	27	90	80	10
N'bnd	80	24	56	79	44	35

It is evident from Table 4-9 and Table 4-11 that overall the actual average speeds at the site as a result of realignment has lead to higher travel speeds at the site than forecasted values for pre-construction economic appraisal stage. One of the main reasons for the differences in speeds is due to the fact that automobile technology has undergone drastic improvement in the past decade. This is specifically applicable to the HCV's for which the power of the engine (power to weight ratio) have significantly improved allowing them to travel at much higher speeds compared to the HCV's that existed about a decade ago.

As indicated in Table 4-11 the 'differential speeds' amongst the cars (lights) and HCV's is far less for the post-construction observed speeds compared to the pre-construction estimate. Differential speeds amongst the lights and heavies determine the size of the passing lane benefits i.e. greater the differential speeds greater is the benefits of having passing lane. It should be noted that there are certain limitations to the use of passing lane travel speeds and they should be borne in mind when using these results. The post-construction speed surveys were not designed to capture the effects of the passing lanes. However, a reasonable effort has been put to extract the speeds in the vicinity of the passing lane from observed travel speeds across the project length.

Re-evaluation of Benefits

The travel time benefits are re-evaluated using the post-construction data to investigate what would be the forecasted benefits if the post-construction traffic data was available at the time of the analysis. Table 4-12 and Table 4-13 include re-evaluated travel time and passing lane benefits respectively

Table 4-12: Re-evaluation of travel time benefits

Criteria	Re-evaluated Post Construction Travel Time Benefits	Pre-Construction Travel Time Benefits	Change
Post-Construction travel speed surveys (A)	$16,110,903	$11,586,907	+39%
Post-Construction Traffic composition alone (B)	$10,733,342	$11,586,907	-7%
Combined effect of (A) and (B)	$13,193,079	$11,586,907	**14%**

Table 4-13: Re-evaluation of passing lane benefits

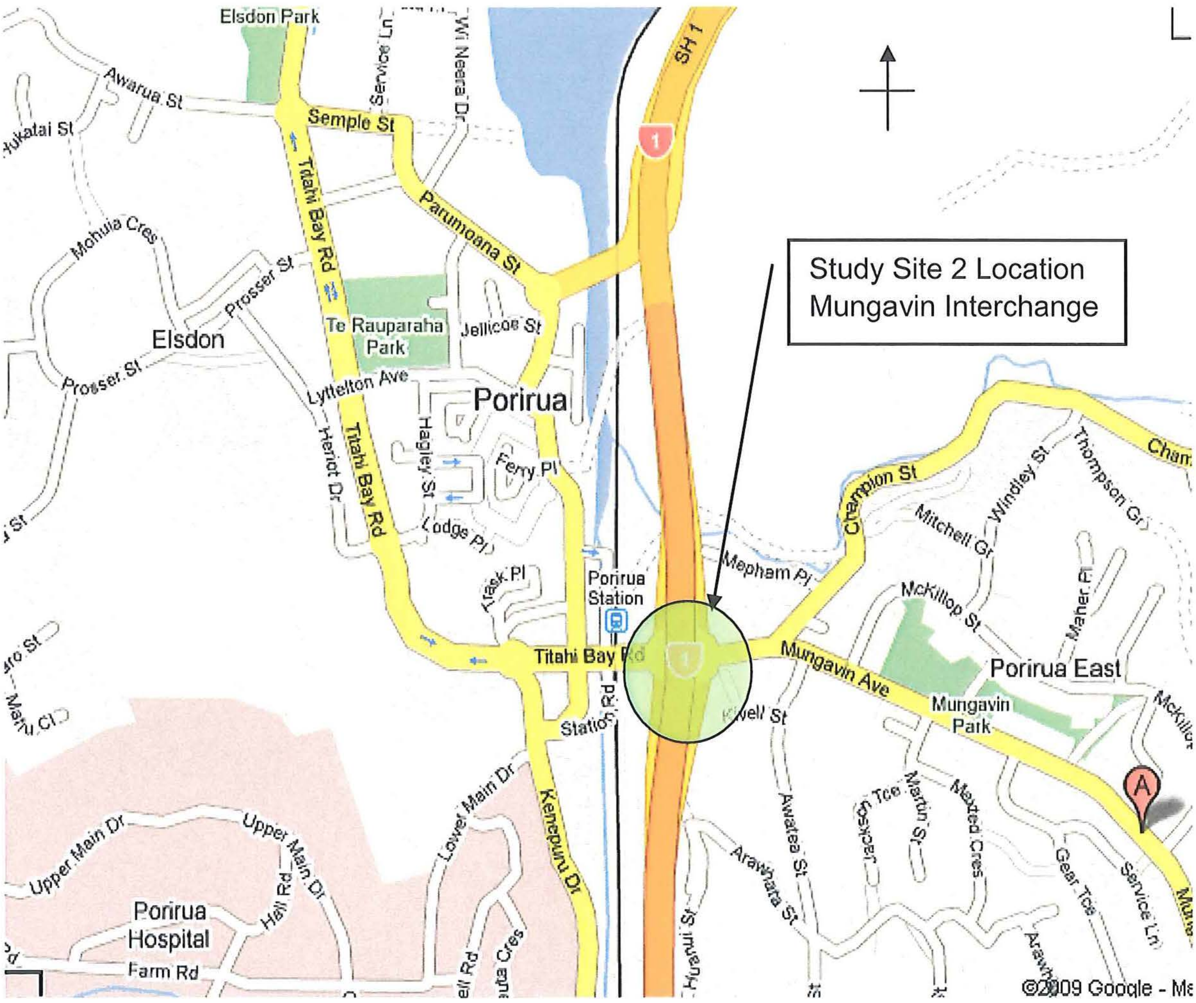
Criteria	Re-evaluated Post Construction Passing Lane Benefits (northbound and southbound)	Pre-Construction Passing Lane Benefits	Change
Post-Construction travel speed surveys	1,567,750	1,376,861	-12%

4.2 Study Site 2 – Mungavin Intersection Upgrade

4.2.1 Pre-construction Analysis

Mungavin Intersection is located 18 km north of Wellington on State Highway No 1 (SH1). As SH1 passes through Porirua, it parallels the railway splitting the city into two. Mungavin Avenue provides the principle access between Porirua East across the SH1 and Railway to Porirua City Centre, the suburbs of Titahi Bay and Tawa Borough. Figure 4-3 includes location of Study Site 2, Mungavin Intersection Upgrade.

Figure 4-3: Location of Study Site 2 – Mungavin Intersection Upgrade



(Please note that project was initially referred as Mungavin Intersection upgrade and currently the same project is referred as Mungavin Interchange. This report refers to this study site as Mungavin Intersection upgrade in most of the cases)

To gain an insight into the problems perceived at the pre-construction phase of the project, an extract from the pre-construction SAR (Ministry of Works and Development, 1985) has been reproduced and included below.

"The problem occurring at this intersection is the delay caused by the conflict between the northbound and southbound State Highway traffic and the east and west bound traffic using Mungavin Avenue. This conflict is causing major delays especially during the AM Peak period. The major source of the problem is the right turning traffic from Mungavin bridge turning south to Wellington conflicting with through traffic travelling from Porirua East to the town centre coupled with the high traffic volumes on the State Highway.

The Two lanes Mungavin Bridge provided a single lane both to and from the intersection. In the peak hour, 60% of vehicles turn right vehicles that frustrate the east/west movement by blocking the Mungavin Bridge and as a result, destroy the potential of the signalisation. The problem is similar but usually less severe from Porirua East because on the eastern approach to the intersection two lanes of channelisation are provided together with a slip lane towards Wellington. Channelisation is also provided on the north and South State Highway approaches to the intersection."

Four different options were investigated as part of the SAR. The options included partial grade separation (Option 1), grade separated diamond interchange (Option 2), grade separated with large roundabout (Option 3) and grade separated with 'Dumbell' roundabout (Option 4). However, Option 3 was identified as the optimal solution which includes State Highway passing under Mungavin Avenue via an underpass but connected to Mungavin Avenue by off and on ramps via a large roundabout. The existing intersection (post-construction layout) mirrors Option 3 (see Figure 4-5) However, it should be noted that many network changes occurred in the immediate vicinity of the Mungavin Intersection upgrade (see section 4.2.3. for more discussion).

Figure 4-4 shows the study aerial photo before the Mungavin intersection was upgraded to grade separated interchange.

Figure 4-5 shows the study area layout after the construction of Mungavin Grade separation Interchange as existing. The intersection of Mungavin Bridge and SH1 is fully grade separated with large roundabout.

Figure 4-4: Mungavin Interchange Pre-construction.

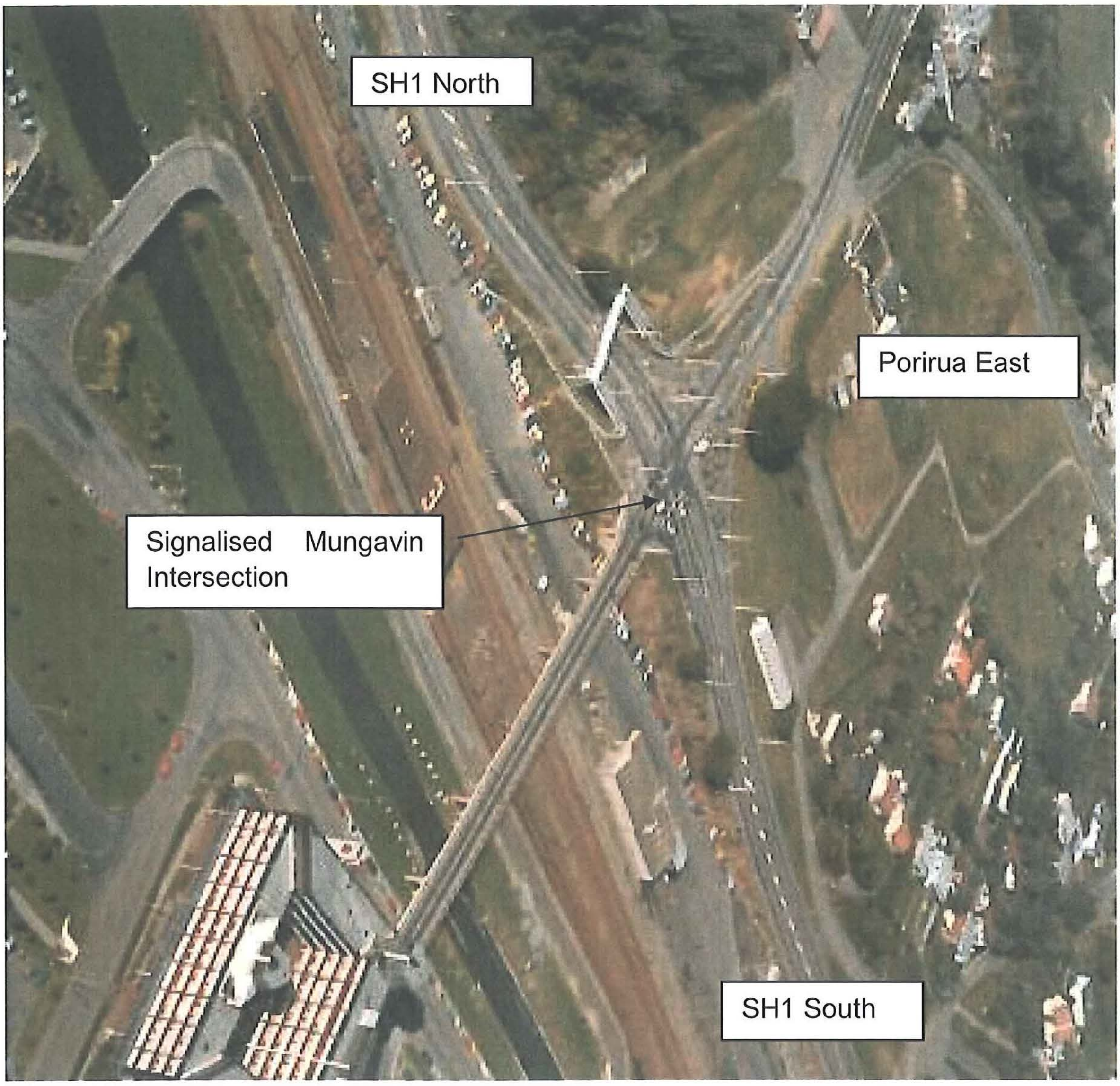


Figure 4-5: Mungavin Interchange Post-construction.

The pre-construction analysis was primarily carried out by calculating travel delays using SIMSET 2 and ROUNDCAP to analyse delays at signalised intersection and roundabouts respectively. SIMSET2 is a microscopic time scan simulation model developed in Australia for analysing traffic performance at signalised intersections (Dunn & Fisk, 1986). ROUNDCAP is an Australian roundabout formula to calculate traffic performance at roundabout intersection. The analysis assumed time zero as 1 April 1986, with start of construction as April 1987 and construction spread over a three year period for the preferred option. The analysis assumed a 25 year analysis period from 1 April 1986 to 1 April 2011 and a 10% discount rate. In addition, a travel time cost multiplier factor of 1.04 was used in the analysis.

As noted above, the pre-construction economic analysis used SIMSET 2 and ROUNDCAP outputs. The calculated traffic delays and hand calculations were used to complete the economic analysis. As part of this research project the pre-construction analysis was investigated thoroughly to gain an insight into underlying assumptions and principles.

The following Table 4-14 and Table 4-15 summarises the Annual hourly characteristics assumed and the calculated travel costs/vehicle/annum used in the preconstruction analysis.

Table 4-14: Annual Hourly Characteristics

Peak Period	Peak Time	No. of Hrs	Days/yr	Hrs/yr
AM	07:00-09:00	2	250	500
IP	09:00-16:30	7.5	250	2250
	18:30-20:00	1.5	250	
PM	16:30-18:30	2	250	500
Weekend	07:00-20:00	13	115	1495
Night	20:00-07:00	11	365	4015

Table 4-15: Annual Delay costs – Travel costs/vehicle/Annum

Peak Period	Travel Time $/hr/yr	$1985 factor	Normal Case (<=50 delay Hrs/hr)		Congested Case (>50 delay Hrs/hr)	
			Normal hr/yr	$/yr	Normal hr/yr	$/yr
AM	$5.15	1.04	500	$2,675.4	1000	$5,350.8
IP	$9.00	1.04	2250	$21,064.7	2500	$23,405.2
PM	$5.27	1.04	500	$2,738.8	1000	$5,477.7
Weekend	$5.25	1.04	1495	$8,156.5	1495	$8,156.5
Night	$5.85	1.04	4015	$24,410.6	3765	$22,890.6

The figures used in the travel costs/vehicle apply to both do-min and option, within a time slice and only need to be multiplied by the total delay and the 10% discount factor for single payment SPPWF pertinent to each year from end of construction to 2011. The sum of this series is the Net Present worth of Travel costs for the options.

The only exception to this is where delay exceeds 50 hours/hr when in subsequent 5 year calculations the number of peak hours in the year increases by 500 with reductions of 250 hours per annum from night and inter-peak. (Ministry of Works and Development, 1985)

Table 4-16 and Table 4-17 include a summary of travel costs for Do-min (signals) and Option (Roundabouts) respectively and Table 4-18 includes a summary of calculated benefits and costs for Mungavin Intersection upgrade at the pre-construction phase.

Table 4-16: Calculated Travel Costs for Existing Intersection

Do Minimum Delay Costs - Existing (Signalised Intersection)											
	AM Peak		InterPeak		PM		Weekend		Night		$Total / year
Normal	2675.4		18724		2738.84		8156.4808		22890		
Congested	5350.8		16383.6		5477.68		8156.4808		21370		
	HRS/HR	$/Year	HRS/HR	$/Year	HRS/HR	$/Year	HRS/HR	$/Year	HRS/HF	$/Year	
1986	50.00	$267,540	10.87	$203,530	20.78	$56,913	10.87	$88,661	3.52	$80,573	$697,217
1987											$712,706
1988											$728,196
1989											$743,685
1990											$759,175
1991	50.00	$267,540	11.92	$223,190	35.66	$97,667	11.92	$97,225	3.89	$89,042	$774,664
1992											$812,770
1993											$850,875
1994											$888,981
1995											$927,086
1996	50.00	$267,540	13.55	$221,998	50.00	$273,884	13.55	$110,520	4.27	$91,250	$965,192
1997											$973,328
1998											$981,464
1999											$989,600
2000											$997,736
2001	50.00	$267,540	14.99	$245,590	50.00	$273,884	14.99	$122,266	4.52	$96,592	$1,005,872
2002											$1,017,990
2003											$1,030,108
2004											$1,042,226
2005											$1,054,344
2006	50.00	$267,540	17.25	$282,617	50.00	$273,884	17.25	$140,699	4.76	$101,721	$1,066,462
2007											$1,078,223
2008											$1,089,985
2009											$1,101,746
2010											$1,113,508
2011	50.00	$267,540	19.42	$318,170	50.00	$273,884	19.42	$158,399	5.02	$107,277	$1,125,270
Total Travel Costs for Do Minimum (Undiscounted) =											$24,528,411

Table 4-17: Calculated Travel costs for Option (Roundabout)

Option Delay Costs - Option 3(Roundabout+ Grade Seperation)											
	AM Peak		InterPeak		PM		Weekend		Night		$Total / year
Normal	2675.4		21064.68		2738.84		8156.4808		24410.5576		
Congested	2675.4		21064.68		2738.84		8156.4808		24410.5576		
	HRS/HR	$/Year	HRS/HF	$/Year	HRS/HF	$/Year	HRS/HF	$/Year	HRS/HF	$/Year	
1986	4.92	$13,163	2.51	$52,872	5.72	$15,666	2.51	$20,473	0.62	$15,135	$117,308.79
1987	4.92		2.51		5.72		2.51		0.62		$121,197.86
1988	4.92		2.51		5.72		2.51		0.62		$125,086.93
1989	4.92		2.51		5.72		2.51		0.62		$128,976.00
1990	4.92		2.51		5.72		2.51		0.62		$132,865.06
1991	5.39	$14,420	2.99	$62,983	6.17	$16,899	2.99	$24,388	0.74	$18,064	$136,754.13
1992	5.39		2.99		6.17		2.99		0.74		$141,682.07
1993	5.39		2.99		6.17		2.99		0.74		$146,610.00
1994	5.39		2.99		6.17		2.99		0.74		$151,537.94
1995	5.39		2.99		6.17		2.99		0.74		$156,465.87
1996	5.95	$15,919	3.62	$76,254	6.65	$18,213	3.62	$29,526	0.88	$21,481	$161,393.81
1997	5.95		3.62		6.65		3.62		0.88		$165,052.45
1998	5.95		3.62		6.65		3.62		0.88		$168,711.08
1999	5.95		3.62		6.65		3.62		0.88		$172,369.72
2000	5.95		3.62		6.65		3.62		0.88		$176,028.36
2001	6.51	$17,417	4.03	$84,891	7.16	$19,610	4.03	$32,871	1.02	$24,899	$179,687.00
2002	6.51		4.03		7.16		4.03		1.02		$184,427.02
2003	6.51		4.03		7.16		4.03		1.02		$189,167.05
2004	6.51		4.03		7.16		4.03		1.02		$193,907.08
2005	6.51		4.03		7.16		4.03		1.02		$198,647.11
2006	7.30	$19,530	4.59	$96,687	7.73	$21,171	4.59	$37,438	1.17	$28,560	$203,387.13
2007	7.30		4.59		7.73		4.59		1.17		$208,381.26
2008	7.30		4.59		7.73		4.59		1.17		$213,375.39
2009	7.30		4.59		7.73		4.59		1.17		$218,369.51
2010	7.30		4.59		7.73		4.59		1.17		$223,363.64
2011	8.29	$22,179	5.19	$109,326	8.32	$22,787	5.19	$42,332	1.30	$31,734	$228,357.76
Total Travel Costs for Option (Undiscounted) =											$4,443,110

Table 4-18: BCR Summary of Mungavin Intersection

	Do Minimum	Option	Benefits / Costs	% of total benefits
Travel Time Costs (TTC)	$6,640,962	$1,175,630	$5,465,332	**67%**
Accident Costs	$2,841,480	$123,330	$2,718,150	33%
Total Benefits (PV)			**$8,183,482**	
Costs (incl. addtn'l maintenance costs)		$157,500	$3,875,040	
Total Costs (PV)			**$3,875,040**	
BCR =			**2.1**	

4.2.2 Post-construction Analysis

Though the pre-construction analysis used SIMSET 2 and ROUNDCAP to determine the delays at the intersection, the post construction analysis was carried out using SATURN traffic model. The reasons for the using SATURN as opposed to pre-construction analysis software are:

- The pre-construction analysis analysed and appraised the project in 'isolation' and did not include the 'network wide effects' of this important intersection (i.e. interchange) on SH1 and other parts of the network. These effects cannot be ignored and accordingly the SATURN model which is a powerful network wide traffic modelling tool was chosen for the post-construction analysis.
- Access and ability to use 'outdated' traffic models for the post-construction analysis

As noted above, the strategic assessment of the network has been carried out using a SATURN traffic model. For this analysis, a validated SATURN model, initially developed for the purposes of the Transmission Gully (TG) project was used. The TG project SATURN model was initially developed by Sinclair Knight Merz (SKM) on behalf of Transit New Zealand (Now NZTA).

In order to use the SATURN model for the purpose of post-construction analysis, the TG SATURN model (Test 58, which is more relevant for the existing (2008) situation) was modified to analyse the pre-construction (do-minimum, signalised intersection) situation of the network. This was achieved by removing the existing Mungavin Interchange (roundabout, post-construction situation) and coding the pre-construction situation i.e. signalised intersection of the network. The SATURN modelling notes given below includes assumptions and notes made during the SATURN modelling process.

- SATURN version 10.6.14 was used for all the assignments due to the model validation based on this version.
- For a reasonable comparison, only 2006 models were used for the analysis, as the pre-construction analysis does not forecast travel time benefits beyond year 2011. The next TG forecast SATURN models start from year 2016 that includes future network changes and permitted developments.
- TG SATURN models are available for AM, IP and PM peak periods only. Accordingly, only these peak periods models were used in the analysis.
- All peak time periods of the TG models with no Transmission Gully (Test 58) has been used as Post-construction Mungavin interchange layout.
- The signalised Mungavin/SH1 intersection is coded as per pre-construction layout and phasing of the Mungavin interchange. The details of the pre-construction layout and phasing arrangement were obtained from the pre-construction SAR (Ministry of Works and Development, 1985).
- Optimised Signal settings were used for pre-construction analysis.
- Apart from the Mungavin interchange, all other network layouts are the same as per existing in model year 2006.
- Bus time and route are as per existing in model year 2006, but node numbers are adjusted to cope with the signalised intersection.

Refer to Figure 4-6, Figure 4-7 and Figure 4-8 for the Pre-construction SATURN layout, Mungavin intersection layout and signal phasing signal respectively. Figure 4-9 includes the post-construction SATURN layout.

Refer to Table 4-19 and Table 4-20 for pre-construction and post-construction SATURN model results.

Figure 4-6; Mungavin Interchange Pre-construction (SATURN Layout)

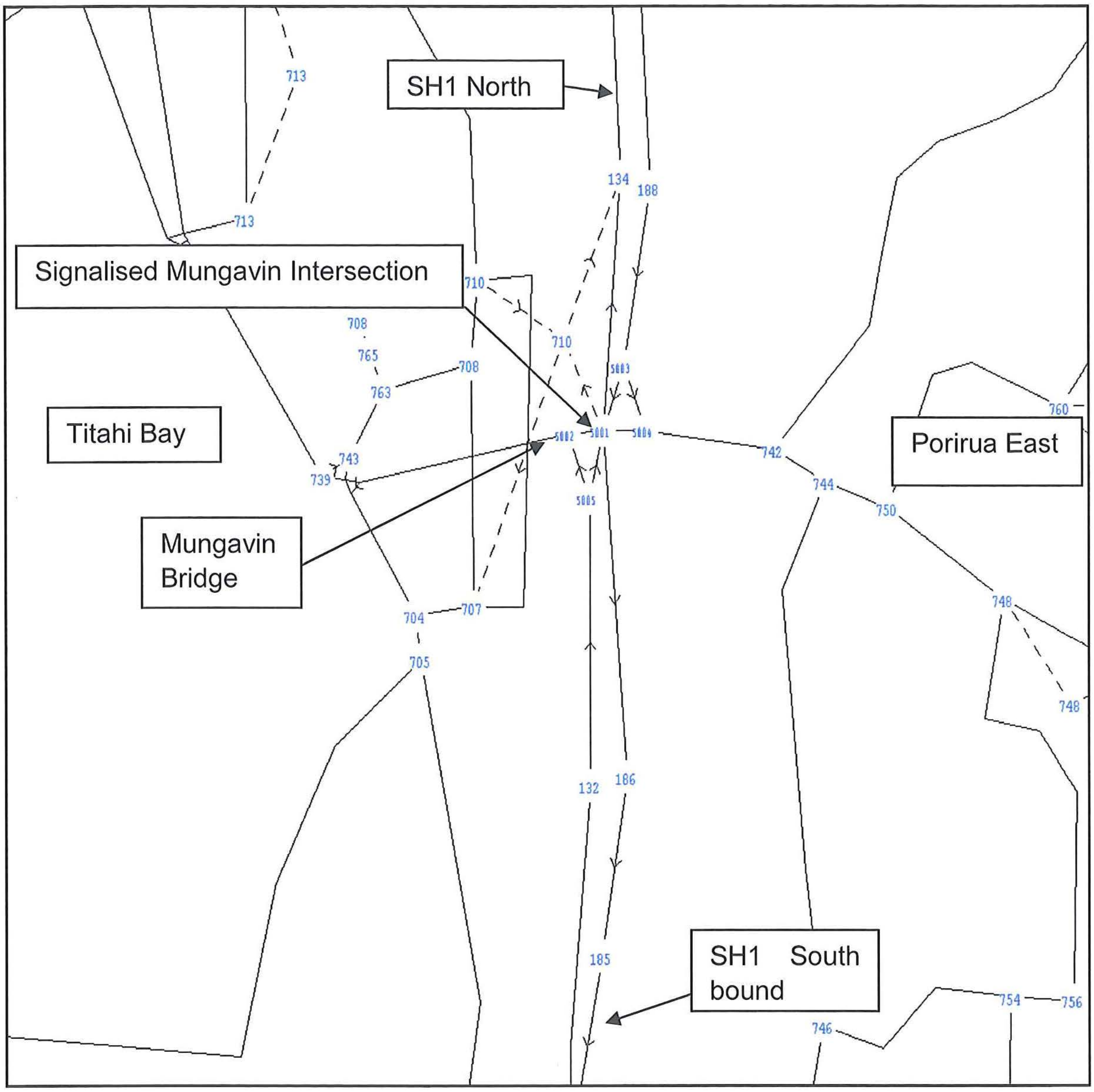


Figure 4-7: Pre-construction Mungavin Intersection layout

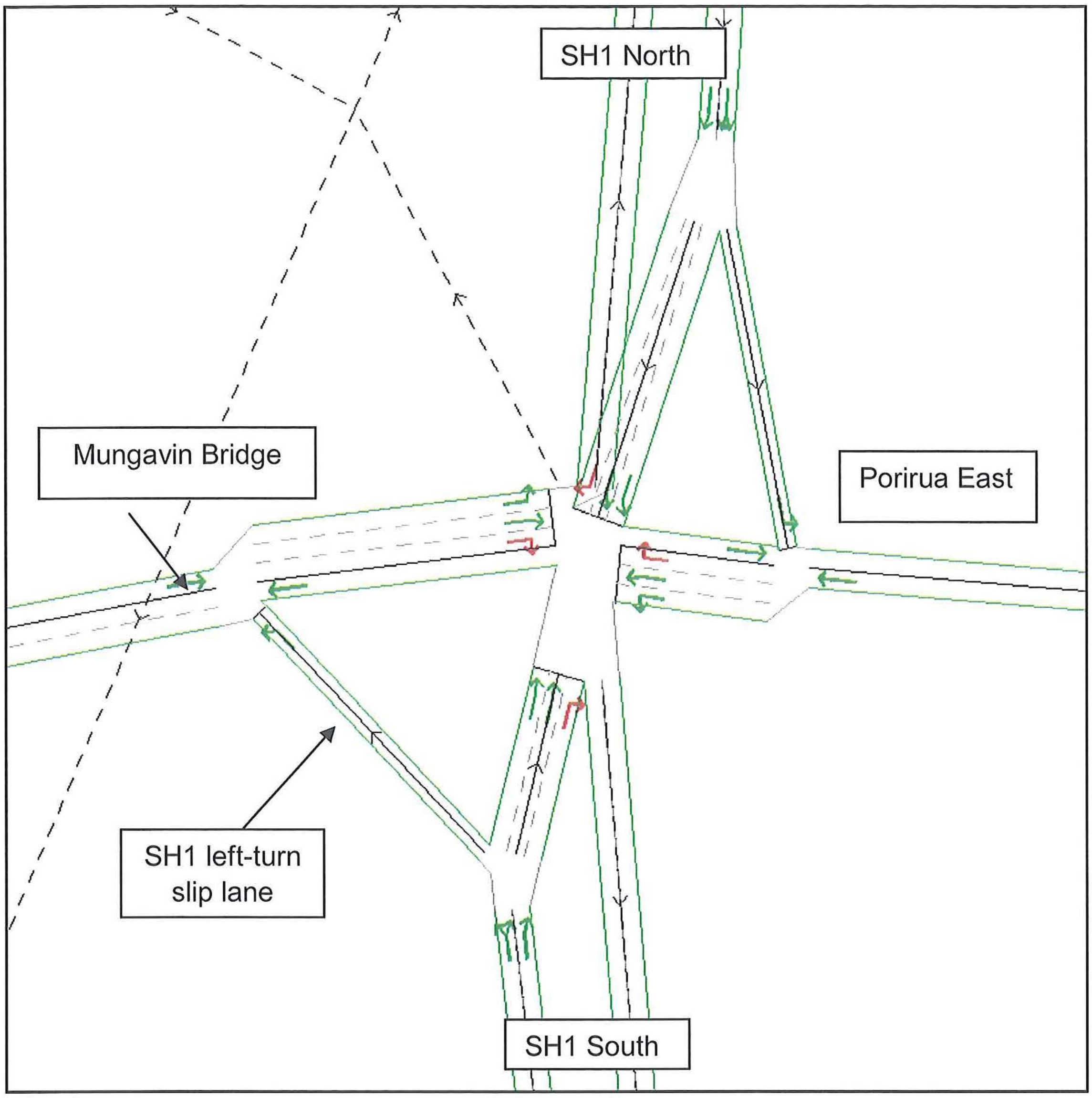


Figure 4-8: Phasing Coded in SATURN as per Pre-construction phasing arrangement

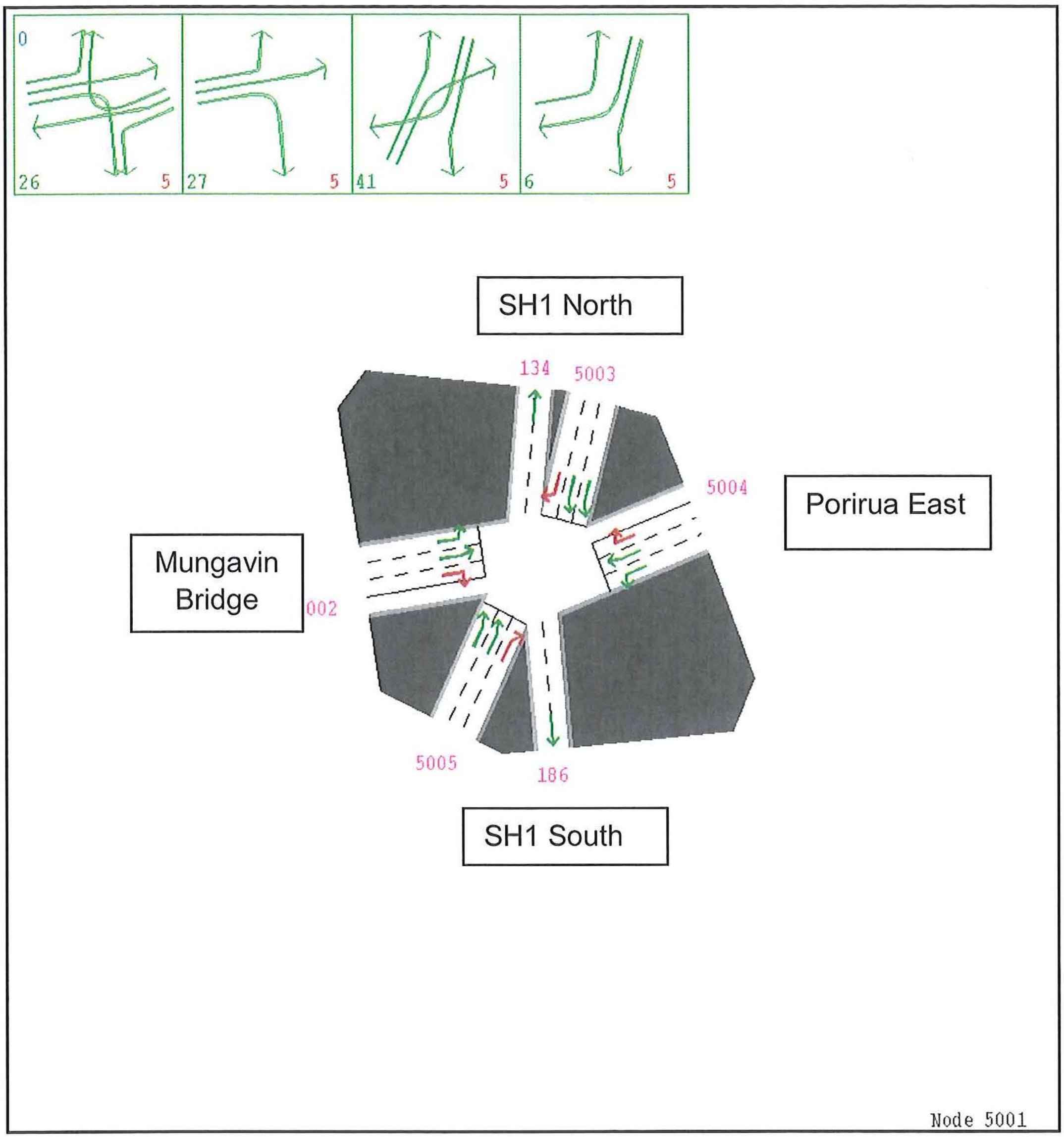


Figure 4-9: Mungavin Interchange Post-construction (SATURN)

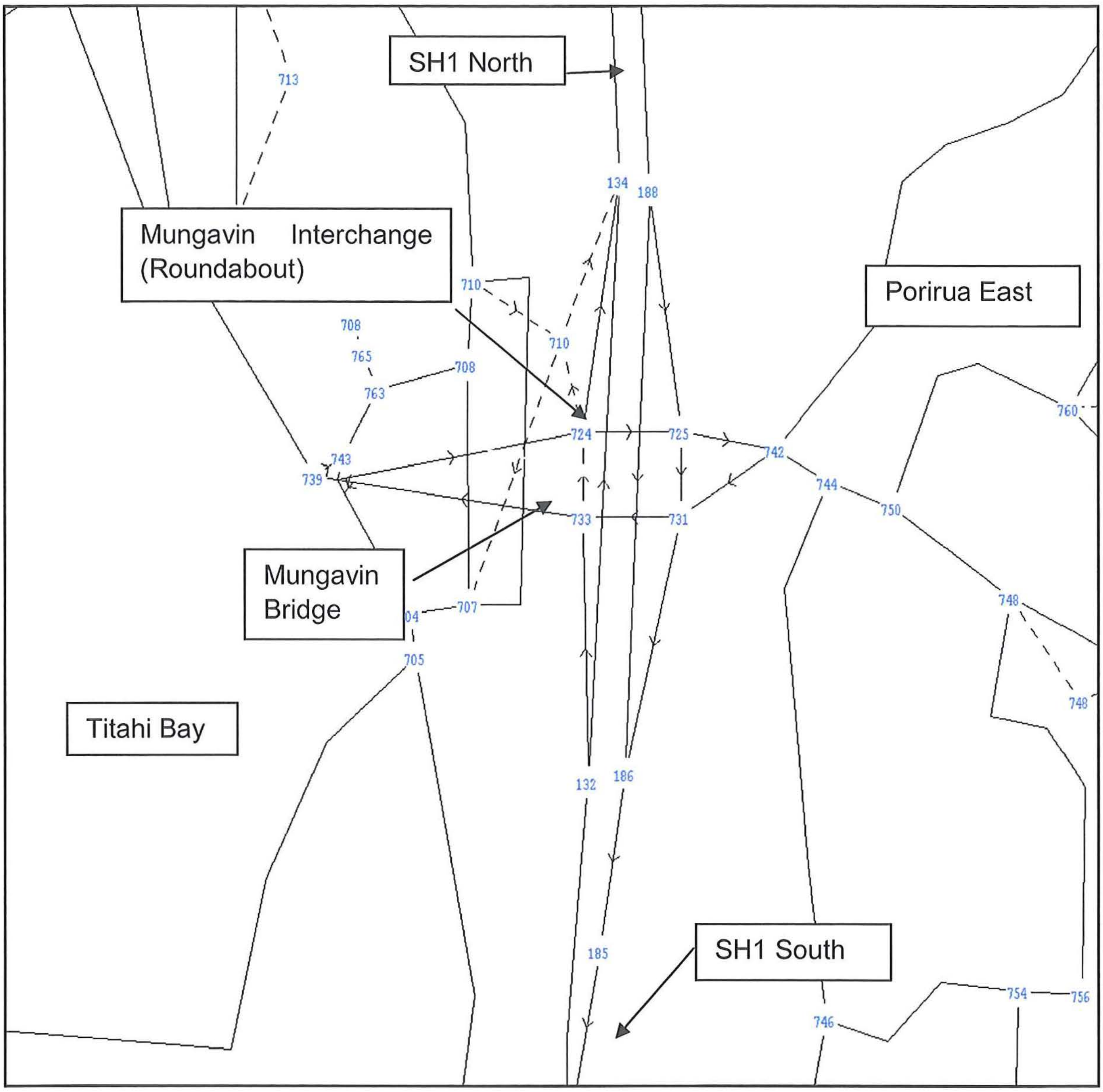


Table 4-19: 2006 Pre construction (Signals) SATURN Results summary

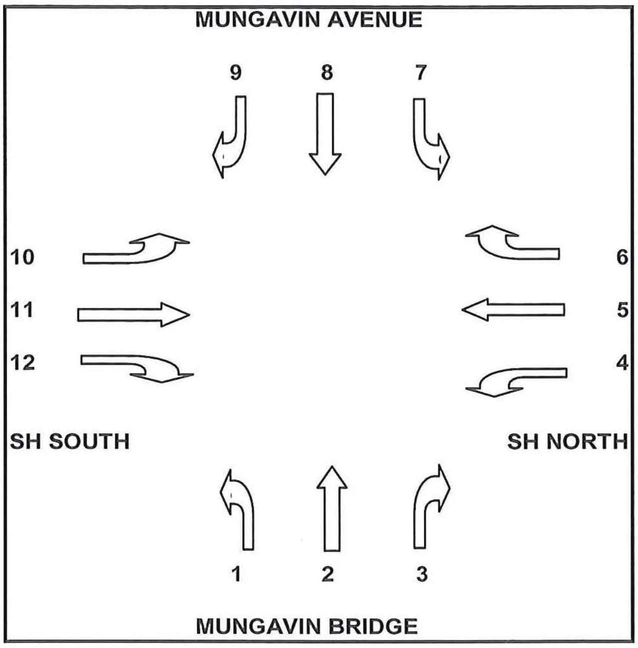
Performance Measure (Units)	AM	IP	PM
Network average travel speed (kms/hr)	54.3	61.2	54.9
Total trips assigned (pcus)	33557	31445	43772
Total vehicle distance (pcu-km)	340665.9	225792.9	377669.0
Total travel time (pcu-hrs)	6277.6	3688.3	6875.1
Total delayed time (pcu-hrs)	351.9	20.2	277.5
Total queued time (pcu-hrs)	410.9	180.2	474.6

Table 4-20: 2006 Post construction (Roundabout) SATURN Results summary

Performance Measure (Units)	AM	IP	PM
Network average travel speed (kms/hr)	54.5	62.5	56.4
Total trips assigned (pcus)	33557	31445	43772
Total vehicle distance (pcu-km)	344740.8	224663.2	375347.2
Total travel time (pcu-hrs)	6319.9	3593.9	6654.2
Total delayed time (pcu-hrs)	391.1	19.8	269.3
Total queued time (pcu-hrs)	367.5	147.7	399.3

Please note that even through changes in demands have already been reflected in the modelling a comparison of Pre-construction forecasted traffic flows against Post-construction traffic flows is included in Figure 4-10

Figure 4-10: Comparison of Pre-construction vs. Post-construction forecasted traffic flows for roundabout option

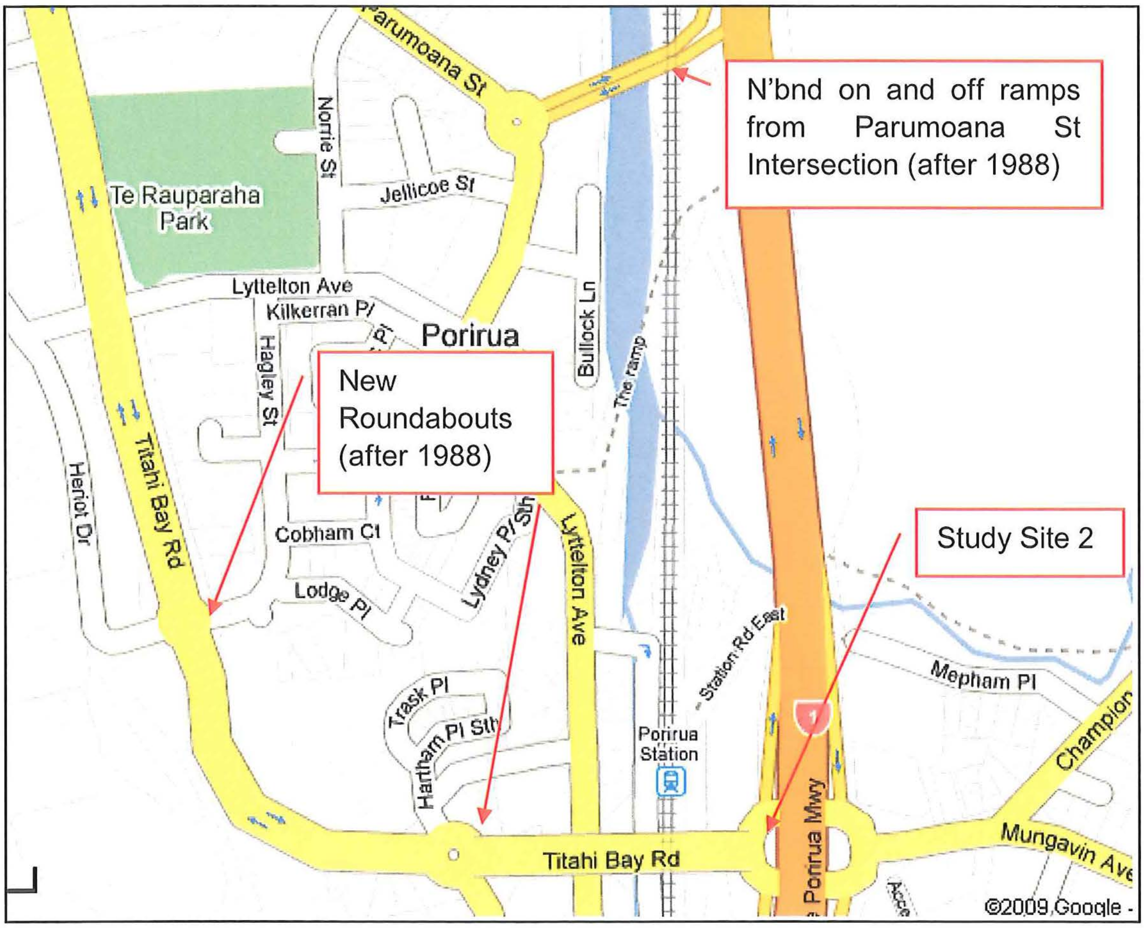


ROUNDABOUT & GRADE SEPARATED OPTION FORECASTS									
MOVEMENT	PRE CONSTRUCTION			POST CONSTRUCTION			DIFFERENCES		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
1	57	62	82	400	71	196	343	9	114
2	252	342	527	473	738	454	221	396	-73
3	477	288	298	89	62	162	-388	-226	-136
4	400	314	540	186	51	153	-214	-263	-387
5	*G.S*	*GS*	*GS*	*G.S*	*GS*	*GS*			
6	60	59	350	307	182	89	247	123	-261
7	277	92	48	187	242	328	-90	150	280
8	532	393	333	235	686	879	-297	293	546
9	47	53	12	584	567	599	537	514	587
10	383	68	190	361	504	657	-22	436	467
11	*GS*	*GS*	*GS*	*G.S*	*GS*	*GS*			
12	40	36	17	134	154	479	94	118	462

4.2.3 Results and Discussion

As described in 4.2.1 the pre-construction analysis was carried out by considering the effects of improvements in isolation i.e. independent of the effects on wider network and vice-versa. The primary difference in pre-construction analysis and post-construction analysis not only relates to appropriate traffic model but also the network changes, traffic growth and permitted developments that have occurred in the past 20 year. For example, intersection improvements to the immediate northern and western side of the study site in consideration are included in Figure 4-11.

Figure 4-11: Example of network changes in the vicinity of Study Site 2



The SATURN model results in Table 4-19 and Table 4-20 indicate that with current Mungavin Interchange (post-construction layout) in place there are significant benefits for the network in terms of reduction in travel time and release of congestion. This is evident from the results indicating that that the overall travel time and the congested travel times (i.e. travel time on links and turns respectively) have reduced significantly for both the IP and PM peak periods. Though, these reductions appear reverse in the AM Peak, in practice, they will have a reasonable impact on the performance of the network as a whole. This is due to the fact that the inter peak (assuming it is something similar to the off-peak and weekend peak) and PM peak constitute to a larger proportion of the total day against the AM periods.

Re-evaluation of Benefits

The travel time benefits have been re-evaluated using the post-construction modelling to investigate the forecasted benefits. However, as noted earlier in 4.2.2 for a reasonable comparison only the 2006 benefits have been reported and included in Table 4-21.

The re-evaluated benefits have assumed the same travel time costs and annualisation factors used in the pre-construction analysis. A summary of the re-evaluated benefits calculations included in Appendix E of this report.

Table 4-21: Comparison of re-evaluated travel time benefits for year 2006.

Description	Re-evaluated Post Construction Travel Time Benefits	Pre-Construction Travel Time Benefits
Travel benefits (2006) – undiscounted to time zero 1986	3,427,047	$863,075
Travel benefits (2006) – discounted to time zero 1986	$514,057	128,292

One of the main issues is to separate/estimate the level of benefits an important intersection improvement as Mungavin Intersection on SH1 on its own would contribute to the network. Though this is covered up to some extent by inclusion of similar network changes/assumptions that have occurred over the years both in the dominium and option modelling scenario, it would be unclear regarding the size of benefits or disbenefits and the effect of other network changes on the study site under consideration and vice-versa. The trip assignment on the network with current traffic volumes minus other network changes that have occurred over the years would be completely different from current traffic volumes plus the network changes that have occurred over the years.

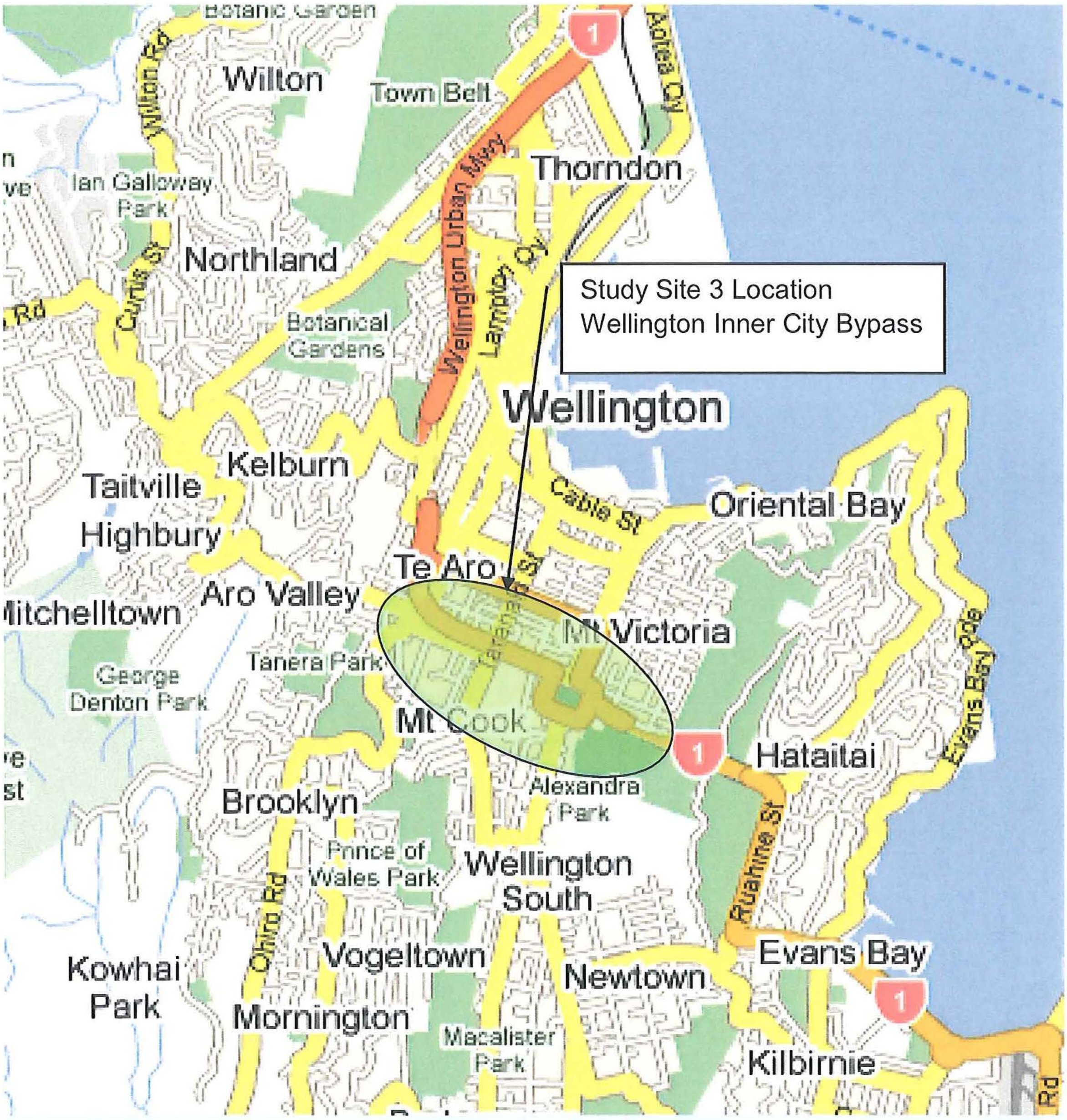
The only way to overcome these issues would be to conduct a post-construction review sooner than later. This will avoid the issues of separating the network changes or other developments that might occur in the later stages post-construction era and thus influencing the whole travel behaviour and trip assignment across the network.

4.3 Study Site 3 – Wellington Inner City Bypass

4.3.1 Pre-construction analysis

The Wellington Inner City Bypass (WICB) project extends from the Southern Portal of the Terrace Tunnel to the Basin Reserve. As such it is part of the strategic route linking the airport to the Wellington region. Figure 4-12 includes location of Study Site 3, Wellington Inner City Bypass.

Figure 4-12: Location of Study Site 3, Wellington Inner City Bypass



An overview of the problem perception and the description of the option at the pre-construction phase of the project has been reproduced from Opus (2001) is given below.

A long-standing deficiency with the Wellington Central Area is the lack of desirable route continuity for the strategic arterial network. This deficiency can be traced back to when the city was originally laid out in the 1840's followed by infrastructure development in an ad hoc way as the city grew. The bypass is proposed in response to the need for an arterial roading structure as part of the strategic route linking the airport to the Wellington region.

In the more immediate term, there is a justification for the Bypass in terms of congestion which leads to frustrating delays for motorists, pedestrians, and public transport passengers. The traffic flow problems that the proposed Bypass will address are:

- *Long queues on the Motorway during the morning and to a lesser extent in the evening peak.*
- *Combination of "through traffic" and "local traffic" functions mixing in Te Aro which leads to congestion.*
- *Accessibility to inner city businesses is being increasingly compromised.*
- *Pedestrians are having increasing difficulty and delays in moving around the Te Aro area.*

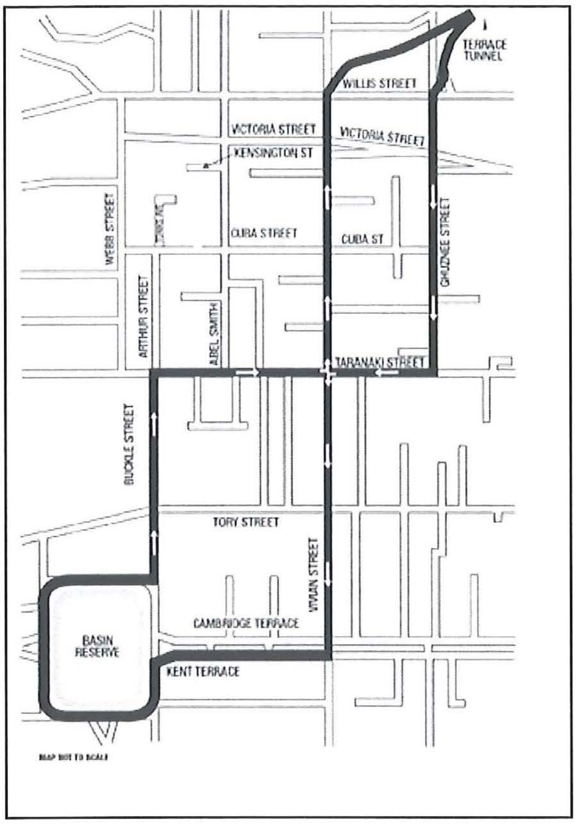
The WICB project involves a paired system of one way streets whereby:

(i) SH1 southbound traffic once through the Terrace Tunnel will travel straight down the two lane one way Vivian Street and on to Cambridge/Kent Terrace which will remain one way to the Basin Reserve as at present. To facilitate this, what currently functions as the Motorway on-ramp for northbound traffic from Vivian Street will become the Motorway off-ramp for southbound traffic.

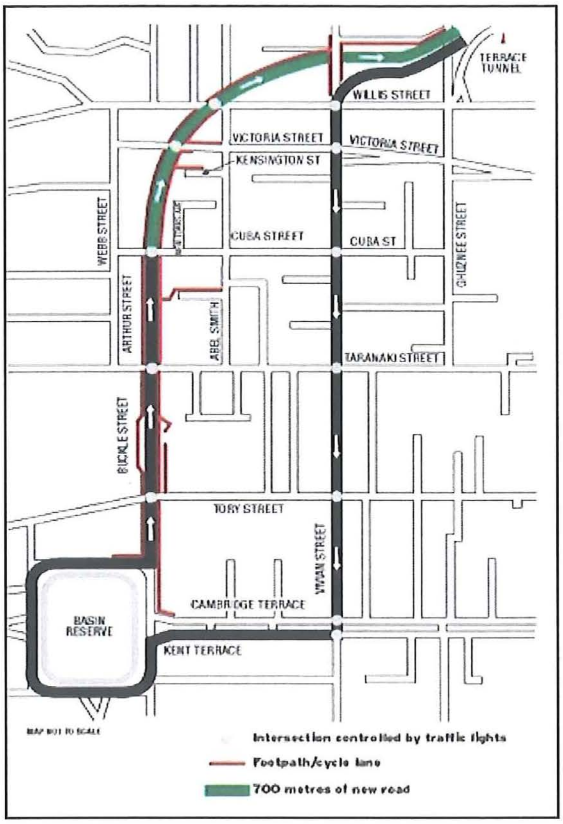
(ii) SH1 northbound traffic will take a two lane route from Buckle Street (to be realigned) and Arthur Street (to be widened and realigned). Traffic will then pass along a new section of road to be constructed starting at Cuba Street/Arthur Street/Tonks Avenue intersection curving across Victoria Street and then through the intersection of Willis and Abel Smith Streets. This new section of road will then pass through a cutting under a new Vivian Street Over-bridge and on to the Terrace Tunnel.

Figure 4-13 includes route schematic of the preconstruction and post-construction routes.

Figure 4-13: Pre-construction & Post-construction routes



Pre-construction (existing)

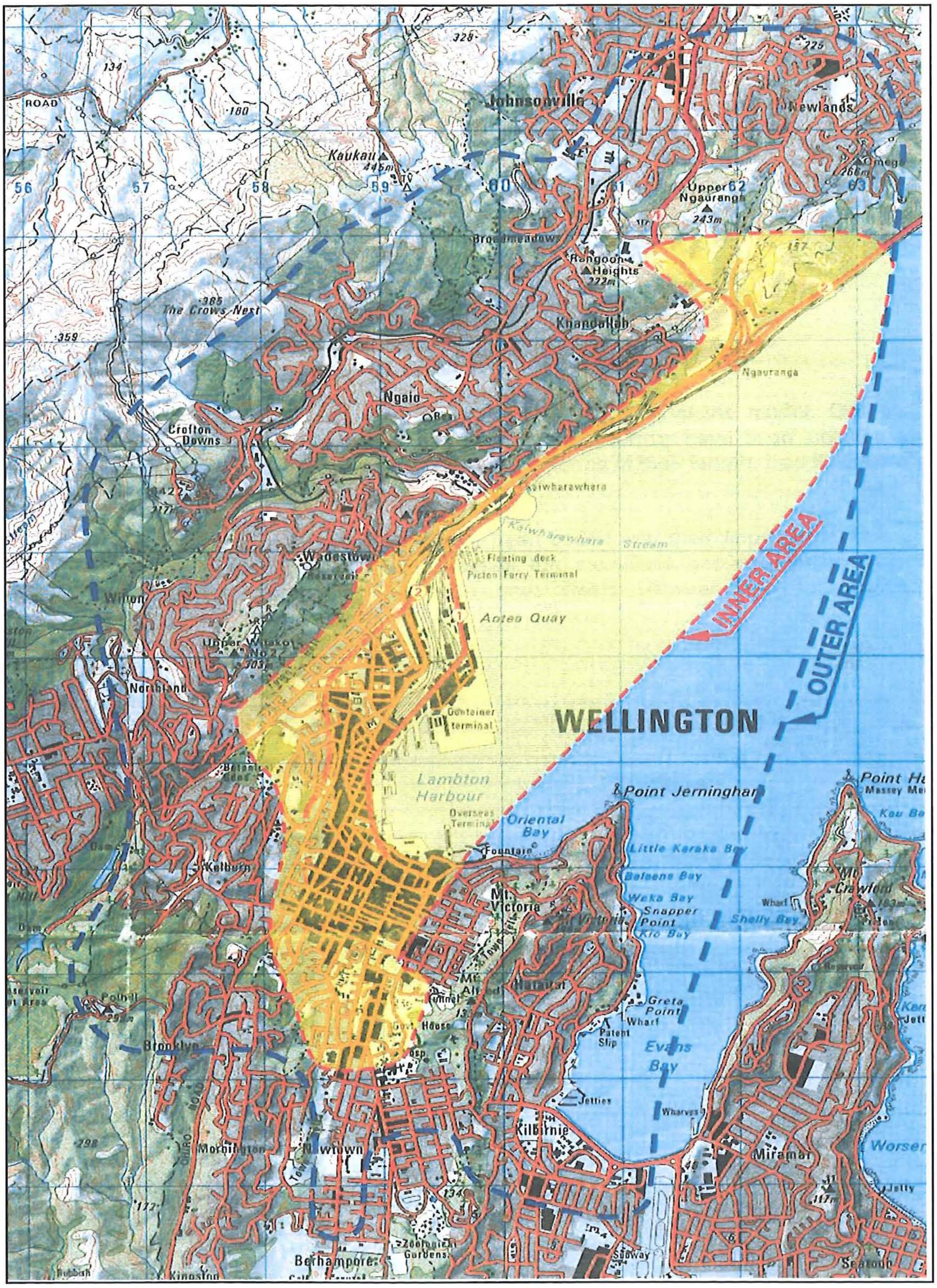


Post-construction (WICB)

Source: Opus International Consultants Ltd (2001)

The pre-construction analysis used a calibrated and validated (Opus, 2000) Wellington City SATURN traffic model that provided most of the inputs to economic analysis. The geographic extent of the model is shown in Figure 4-14. The outer area extends from Kilbirnie / Berhampore in the south to Newlands / Johnsonville in the north. The western extent of the model lies between Northland and Karori. The inner area covers essentially the Central Business District CBD). Within the inner area, intersection delays are simulated in detail. The outer area, or 'buffer' network, is modelled to a lesser degree of detail, since intersection delays in these areas are not primary determinants of route choice. (Opus, 2000)

Figure 4-14: Geographic Extent of SATURN model (2000)



Source: Opus International Consultants Ltd (2000)

The principal benefits of the scheme (94%) derived from travel time savings associated with congestion relief. These benefits have been assessed through the development of a SATURN traffic model. The remaining benefits derive from savings in vehicle operating costs, accident costs and pedestrian delays.

The traffic model generates statistics relating to total travel time in the network for each year, time period and option. This is the summation of the total time spent on road sections and queuing at intersections, and is expressed as the number of vehicle hours in each period. Unit values of time are applied to these statistics to give an economic value of travel time costs. These unit values, defined by the PEM, vary by time period, reflecting the differing proportions of commuter and business traffic. The values adopted in the pre-construction analysis are included in Table 4-22 below.

Table 4-22: Travel Time Cost ($/hr): Pre-construction Analysis

Time Period	Travel Cost ($/vehicle/hour), July 1998
AM Peak	14.40
Inter Peak	17.85
PM Peak	13.75
Saturday	13.40

These travel time cost values relate to July 1998, and have been adjusted using an Update Factor of 1.01 specified in the PEM. Time Zero is assumed as 1 July 1999. The analysis period is assumed to start at Time Zero and finish 25 years from the year in which significant construction commences. The analysis period therefore runs between 1 July 1999 and 1 July 2026. The scheme is assumed to open on 1 July 2003, preceded by a two year period of construction.

The SATURN model outputs used in the pre-construction economic appraisal of the project have been included in Table 4-23. The SATURN modelling results indicate that with WICB in place there are significant benefits for the network in terms of reduction in travel time and release of congestion. It is evident from the results that that the pre-construction analysis forecasts a significant reduction in total network travel time and the congested travel times for both the AM and PM peak periods. The inter peak travel time reductions are not significantly high compared to the AM and PM peak periods. However, they may have a reasonable impact on the performance of the network as a whole is it assumed that off-peak and Weekend peak have a similar impact as inter peak periods as these periods all together constitute a larger period of the total day against the AM and PM peak periods.

Table 4-23: Summary of SATURN model outputs used in Pre-construction economic appraisal, 2001

Performance Measure	Units	Do-Min			Option (WICB)		
		AM	Inter	PM	AM	Inter	PM
Network average travel speed	kms/hr	52.9	57.5	54.6	53.1	57.8	54.7
Total vehicle distance	pcu-kms	223,218	142,722	174,638	223,677	142,711	174,751
Total network travel time	pcu-hrs	11,473	3,130	5028	11,179	3,111	4,764
Total congested travel times	pcu-hrs	7,255	649	1830	6964	643	1570

As part of the WICB project monitoring process and WICB review project, journey time surveys and traffic flow analysis was carried out for the pre-construction and post-construction the project. The author himself was involved in most part of these surveys and analysis from year 2005 in his current role at opus International Consultants Ltd. The author has obtained the permission from NZTA to use and include the journey time surveys and traffic flow analysis in his research project which was carried out as part of the WICB project.

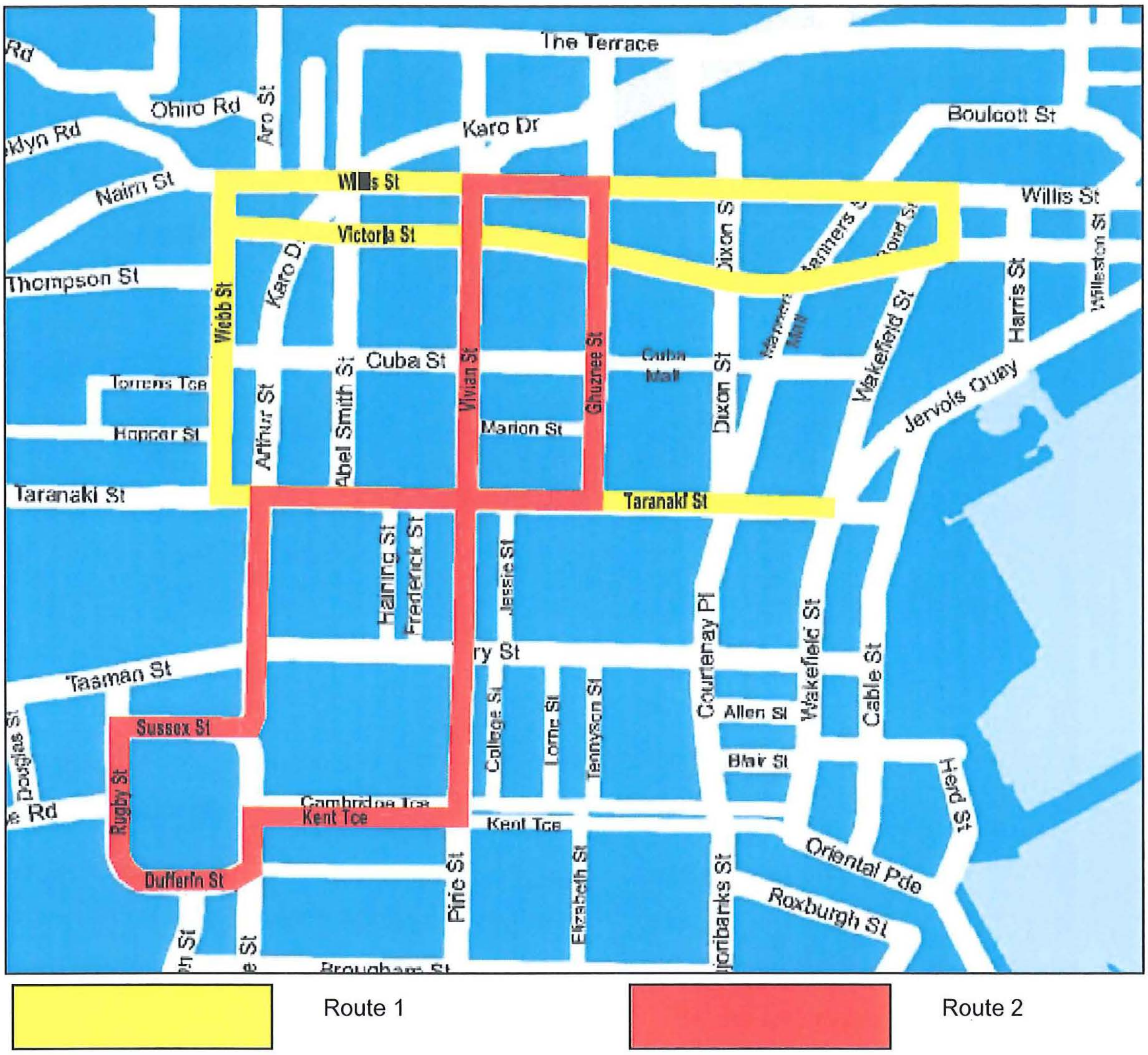
Journey Time Surveys

As part of the WICB project monitoring process, pre-construction journey time surveys were recorded on both the State Highway and local networks before construction of WICB. The pre-construction travel time surveys were undertaken for the following time periods in July 2005.

- AM Peak : 7:00am to 9:00am
- Inter Peak : 12:00pm to 2:00 pm and
- PM Peak: 4:00pm to 6:00pm

The route surveyed is shown in Figure 4-15. The route had a start, a finish and intermediate timing points. The routes were driven in a car with a passenger recording the time at pre-defined points along the route. A time management macro was used to record the time according to the laptop's internal clock into a Microsoft Excel spreadsheet to reduce the likelihood of errors

Figure 4-15: Pre-construction journey time route, July 2005



Source: Opus International Consultants Ltd (2008)

To allow for an evaluation between the pre-construction and post WICB construction journey times, each route was divided into sections such that a reasonable level of comparison could be made.

Route 1 for all pre and post construction surveys were split into the following four sections:

- Taranaki Street at Wakefield Street (Southbound) to Webb Street at Willis Street
- Webb Street at Willis Street to Willis Street at Ghuznee Street
- Victoria Street at Ghuznee Street to Victoria Street at Webb Street
- Victoria Street at Webb Street to Taranaki Street at Wakefield Street (Northbound)

Route 2 for all pre and post construction surveys were split in to the following three sections:

- SH1 Southbound at Willis Street to Vivian Street at Kent Terrace
- Vivian Street at Kent Terrace to Buckle Street at Taranaki Street
- Buckle Street at Taranaki Street to SH1 Northbound at Willis Street

However, in order to reduce and avoid repetition of the analysis carried out by Opus (2008) and reproduce the same results in this research report, only combined travel time results of Route 1 and Route 2 have been included in this report.

The travel distance for each of the local road sections of Route 1 is included in Table 4-24. These distances were unaffected by the construction of the WICB, and have therefore remained constant throughout all of the surveys completed. However, for Route 2, due to the WICB project, the distance travelled on the analysis sections between the Terrace Tunnel and the Basin Reserve has decreased by 410m. The travel distance for Route 2 is included in Table 4-25 (Opus, 2008).

Table 4-24: Total distance for Route 1

Route 1		
Sections		Distance (m)
Taranaki St @ Wakefield St (SB)	Webb St @ Willis St	1370
Webb St @ Willis St	Willis St @ Ghuznee St	540
Victoria St @ Ghuznee St	Victoria St @ Webb St	500
Victoria St @ Webb St	Taranaki St @ Wakefield St (NB)	1330
Total		**3740**

Table 4-25: Total distance for Route 2

Route 2			
Section		Distance (m)	
		2005	2008 (Post-construction)
Off SH1 (SB) @ Willis St	Vivian St @ Kent Tce	1110	980
Vivian St @ Kent Tce	Buckle St @ Taranaki St	1350	1350
Buckle St @ Taranaki St	On SH1 (NB) @ Willis St	770	490
Total		**3230**	**2820**

Table 4-26 and Table 4-27 present a summary of the recorded journey times and back calculated mean speeds respectively for the data collected in the July 2005 for Route 1 and Route 2.

Table 4-26: Summary of Journey Time surveys for Route 1 and Route 2, 2005

Time Period	Route 1 – Journey Time (in minutes and seconds)	Route 2 – Journey Time (in minutes and seconds)
AM Peak	18:48	08:52
Inter Peak	17:36	07:56
PM Peak	23:12	12:17

Table 4-27: Summary of calculated mean speed for Route 1 and Route 2, 2005

Time Period	Route 1 – Calculated mean speeds (in kmph)	Route 2 – Calculated mean speeds (in kmph)
AM Peak	11.94	21.86
Inter Peak	12.75	24.43
PM Peak	9.67	15.78

Please note that a discussion of changes in traffic volumes is carried out in section 4.3.2 to avoid repetition of traffic data in each section mainly due to the shear size of this project analysis.

A summary of the benefits and costs calculated during the pre-construction economic appraisal is included in Table 4-28.

Table 4-28: Summary of benefits and cost analysis for WICB

Project Options	Do Minimum	Option	Benefits / Costs	% of total benefits
COSTS :				
Capital Costs	0	30,141,643	30,141,643	
Maintenance Costs	243,269	240,447	-2,822	
Total Costs			**$30,138,821**	
BENEFITS :				
Travel Time Costs (base)	2,396,083,099	2,392,248,715	3,834,384	3.2%
Travel Time Costs (congested)	1,955,995,905	1,844,952,939	111,042,966	93.9%
Veh Operating Costs (distance)	2,090,327,929	2,093,401,270	-3,073,341	-2.6%
Veh Operating Costs (idling)	126,160,478	118,644,238	7,516,240	6.4%
Accident Costs	63,955,230	62,917,998	1,037,231	0.9%
Pedestrian Delays	29,875,222	28,745,005	1,130,217	1.0%
Carbon Dioxide	43,399,840	43,307,871	91,969	0.1%
Induced traffic reduction (2.8%)	Reduction applies to TT, VOC and Carbon Dioxide only.		-3,343,542	-2.8%
Total Benefits (5) to (11)			**118,236,124**	**100%**
BCR =			**3.9**	

Source: Opus International Consultants Ltd (2001)

4.3.2 Post-construction Analysis

Initially, it was envisaged that a calibrated and updated Wellington city SATURN model along with forecast year models would be available by end of January 2009. It was felt to be more appropriate to use a calibrated Wellington City model to investigate the performance of the WICB under current traffic and network conditions. However, due to unseen foreseen circumstances the calibration of the Wellington city model was delayed. Given this situation, the existing 2001 SATURN model used which was used for the Ngauranga to Airport corridor study was updated to 2006 and used in the project analysis. The author himself was partially involved in update of this model along with another Opus employee.

This modelling procedure included the following steps:

(a) Conversion of the revalidated WTSM 2006 Matrices from the WTSM zoning system to the WCC SATURN model zoning system.

(b) The SATURN networks updated to include any changes for the period 2001-2006 and the option of the WICB tested.

The 2006 WTSM matrices have been then run on the updated SATURN networks and the option for the WICB. The 2006 WTSM matrices reflect the latest land use, demographic, economic, traffic and passenger transport data. This includes new demographic forecast for future years developed for the Wellington region consistent with Statistics New Zealand forecasts.

The two models (pre and post construction) for the 2006 WICB SATURN were created for the AM, IP and the PM Peak periods. As mentioned above, the changes on the network (between 2001 and 2006) were applied to both the pre construction (Do Min) and the post construction (Option) to gauge the performance of the WICB alone.

It should be noted that this study did not involve any form of validation process. This means that there are limitations to the modelling and these needs to be understood and borne in mind when using the results that follow. The model limitations are discussed in more detail towards the end of this report.

The list of changes (schemes completed) between 2001 and 2006 included for both the Do Min and Option scenarios are:

- New Peak period bus lanes on Adelaide Rd and Kent Terrace.
- Adelaide Rd between Rugby St and Drummond St Southbound lanes changed from one to two lanes.
- Bus lanes along Lambton Quay (already included, re-checked).
- New bus lane on Hunter St between Lambton Quay and Customhouse Quay (already included, re-checked)
- Bus lanes on Dixon Street with bus only phase ("B").
- 30 km/h speed limits for Lambton Quay, Willis St and Manners St.

- Bus and service vehicle access restriction northbound on Victoria St and Manners St from Dixon St northwards.
- Three laning of Cable St and Wakefield St (Cambridge Terrace to Taranaki St had changed to three Lanes on each direction to match the exiting layout)
- Access to Ferry terminal for Bluebridge – Waterloo Quay/Bunny St
- Four lane approach of Cable St at Cable St/Taranaki St intersection.
- New signalised intersections at :
  - Willis St/Dixon St intersection
  - Customhouse Quay/Waring Taylor St intersection
  - Customhouse Quay/Brandon St intersection
  - Waterloo Quay/Bunny St intersection
  - Hill St/Molesworth St intersection
  - Adelaide /Rugby St intersection

Please note that:

- New intersection layout at Webb St/Willis St intersection was coded for the post-construction model as it was a part of the WICB project.
- Waterloo Quay/Hinemoa St Intersection signal were not coded in the model due to the problems associated appropriate loading of traffic from the SATURN zoning system.

Source: Opus (2008)

A summary of the SATURN modelling results for the updated traffic model (2006) is included in

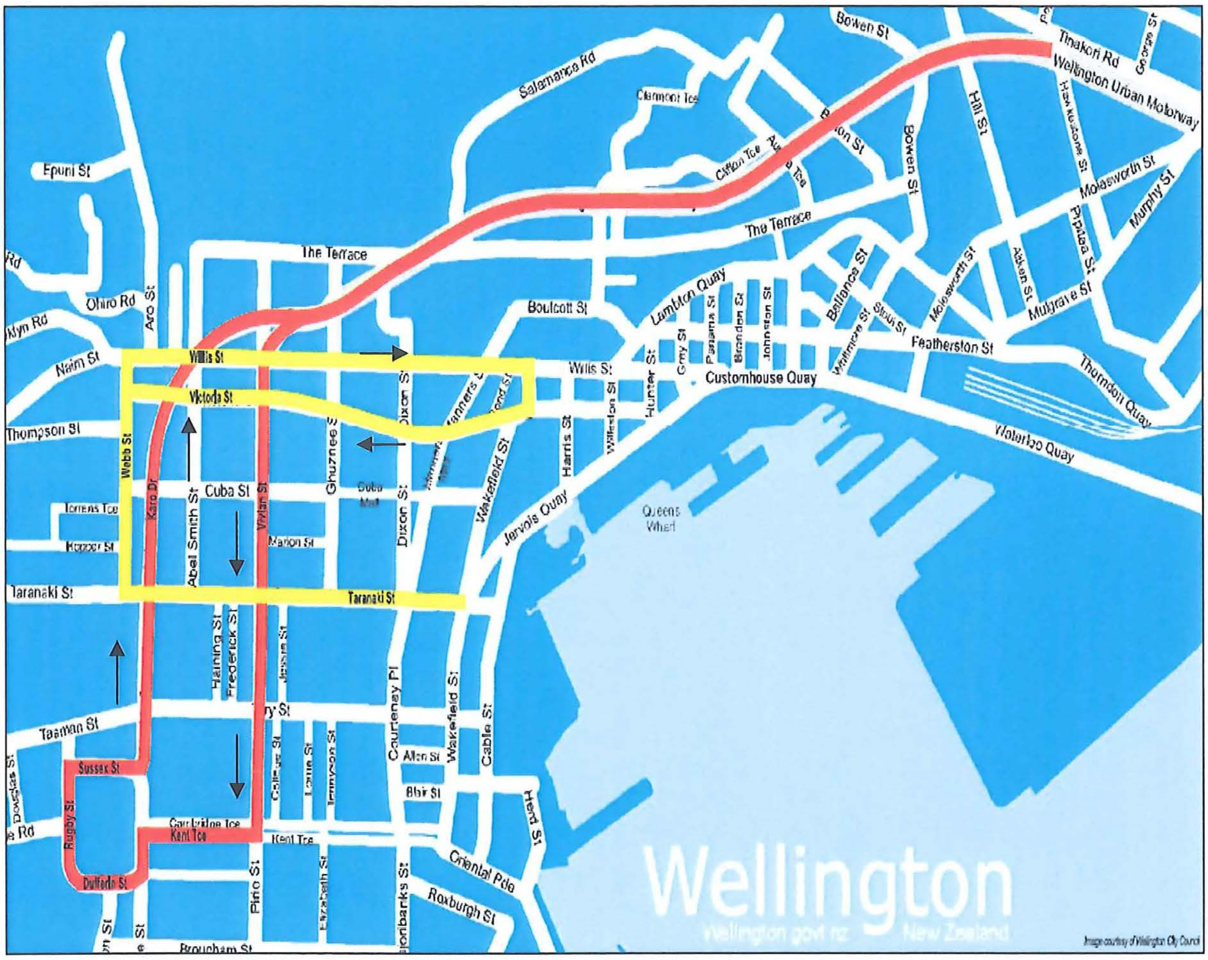
Table 4-29: Summary of SATURN modelling results, Post-construction analysis, 2008

Performance Measure	Units	Do-Min			Option (WICB)		
		AM	Inter	PM	AM	Inter	PM
Network average travel speed	kms/hr	35.9	43.0	37.4	36.3	43.0	38.2
Total vehicle distance	pcu-kms	135,646	98,751	141,942	135,864	98,671	141,301
Total network travel time	pcu-hrs	3,779	2,291	3,790	3,769	2,294	3,696
Total congested travel times	pcu-hrs	1,877	616	1,614	1,841	626	1,529

Journey Time Surveys

Similar to the pre-construction surveys, post-construction journey time surveys were carried out for the same time periods as pre-construction analysis in two different years (August 2007 and July 2008) following the construction of WICB. The route surveyed is shown in Figure 4-16 and follows the same methodology and routes broken down in to same section as pre-construction analysis (refer section 4.3.1) to allow for a reasonable comparison.

Figure 4-16: Post-construction Journey time routes – August 2007 and July 2008



Route 1

Route 2

Source: Opus International Consultants Ltd (2008)

Table 4-30 and Table 4-31 present a summary of the recorded travel times and back calculated mean speeds respectively for the data collected in the July 2005 for Route 1 and Route 2.

Table 4-30: Summary of post-construction journey time surveys, August 2007 and July 2008

Time Period	Route 1 – Journey Time (in minutes and seconds) - 2007	Route 1 - Journey Time (in minutes and seconds) - 2008	Route 2 – Journey Time (in minutes and seconds) - 2007	Route 2 – Journey Time (in minutes and seconds) - 2008
AM Peak	19:04	19:29	06:49	06:31
Inter Peak	17:35	16:54	06:00	06:06
PM Peak	22:35	24:27	10:56	09:08

Table 4-31: Summary of calculated mean speeds, post-construction journey time surveys, August 2007 and July 2008

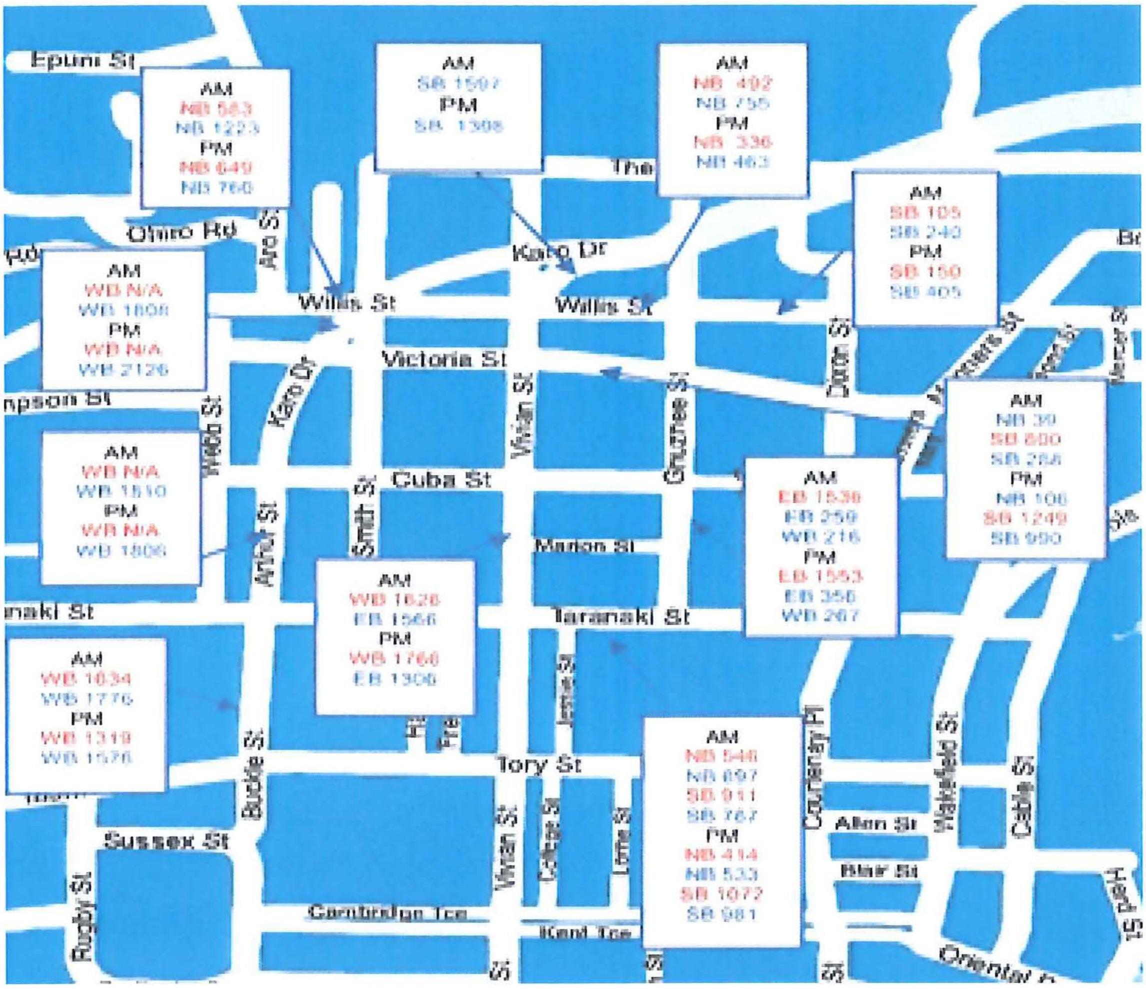
Time Period	Route 1 – Calculated mean speeds (in kmph) - 2007	Route 1 – Calculated mean speeds (in kmph) - 2008	Route 2 – Calculated mean speeds (in kmph) - 2007	Route 2 – Calculated mean speeds (in kmph) - 2008
AM Peak	11.77	11.52	24.82	25.96
Inter Peak	12.76	13.28	28.2	27.74
PM Peak	9.94	9.18	15.48	18.53

Traffic Volumes

Similar to the journey time surveys, as part of the WICB project monitoring process, SCATS data was obtained from Wellington City Council prior for the WICB project (July 2005) and after construction (July 2008). This was to see if there have been measurable changes to the network flow patterns and whether any of these changes could be attributed to the WICB project.

The summary of changes to the traffic flows on key links for Pre-construction and Post-construction is included in Figure 4-17

Figure 4-17: Changes in Traffic Demand, Pre-construction vs. Post-construction



Source: Opus International Consultants Ltd, 2008

Table 4-32 includes differences in Pre-construction and Post-construction traffic demands on the links. It indicates that, on the local road network, significant increases have occurred to north and south bound traffic on Willis Street. On Victoria Street, the southbound movements on Victoria Street have considerably decreased. Despite the removal of SH1 from Taranaki Street, the demands have considerably increased for northbound movements.

Table 4-32: Comparison of Pre-construction vs. Post-construction demand on links

Link	Pre-construction				Post-construction				Difference			
	AM		PM		AM		PM		AM		PM	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
Willis Street (Between Able Smith Street and Aro Street)	583		649		1223		760		640	0	111	0
Willis Street (Between Vivian Street and Ghuznee Street)	492		336		755		463		263	0	127	0
Willis Street (Between Ghuznee Street and Dixon Street)		105		150		240		405	0	135	0	255
Victoria Street (Between Vivian Street and Guznee Street)		800		1249	39	288	106	990	39	-512	106	-259
Ghuznee Street (Between Taranaki Street and Cuba Street)		1536		1553	216	256	267	356	216	-1280	267	-1197
Taranaki Street (Between Jessie Street and Courteney Street)	546	911	414	1072	697	767	533	981	151	-144	119	-91
Vivian Street (Between Taranaki Street and Cuba Street)	1626		1766			1566		1306	-1626	1566	-1766	1306
Buckle Street (Between Tory Street and Taranaki Street)	1634		1319		1776		1576		142	0	257	0

4.3.3 Results and Discussions

The Post-construction SATURN modelling results included Table 4-29 indicates overall size of total travel times and congested travel times on network reduces with bypass in place. However, the size of total travel times and congested travel times on the network is not at the same level as that predicted in the Pre-construction modelling scenario and the ones used in the pre-construction economic appraisal.

One of the main reasons for these differences is due to the absence of a detailed SATURN modelling calibration and validation criteria. The post-construction SATURN modelling process only involved the use of a validated 2006 WTSM matrices and the 2001 validated SATURN network updated to 2006. Other than this process, no formal validation process has been completed for this exercise which may result in the 2006 model not truly representing the current traffic conditions process.

In addition, there can be many reasons that contribute to the under or over estimation of the performance of the network. For example, the 2001 SATURN model used the WTSM matrices which reflected the demographics, land use, economic, traffic and passenger transport data relevant for that time period. The 2006 model update includes the revalidated WTSM matrices that reflect the travel behaviour and traffic conditions at that time. It is very likely that travel behaviour and travel patterns may have changed in response to the limiting network capacity and congested conditions. In an already congested urban environment, any changes to the Socio, economic and transport

Journey time comparisons

A comparison of pre-construction and post-construction travel times and calculated mean speeds Route 1 and Route 2 is included in Table 4-33, Table 4-33, Table 4-34 and Table 4-34.

Table 4-33 : Pre-construction vs. Post-construction Journey Times, Route 1

Route 1 – Journey Time (in minutes and seconds)				
Time Period	**July 2005**	**August 2007**	**July 2008**	**% Change 2005-2008**
AM Peak	18:48	19:04	19:29	4%
Inter-peak	17:36	17:35	16:54	-4%
PM Peak	23:12	22:35	24:27	5%

Table 4-34: Pre-construction vs. Post-construction Mean Speeds, Route 1

Route 1 – Mean Speeds (in kmph)				
Time Period	**July 2005**	**August 2007**	**July 2008**	**% Change 2005-2008**
AM Peak	11.94	11.77	11.52	-4%
Inter-peak	12.75	12.76	13.28	4%
PM Peak	9.67	9.94	9.18	-5%

Table 4-35: Pre-construction vs. Post-construction Journey Times, Route 2

Route 2 – Journey Time (in minutes and seconds)				
Time Period	**July 2005**	**August 2007**	**July 2008**	**% Change 2005-2008**
AM Peak	08:52	06:49	06:31	-27%
Inter-peak	07:56	06:00	06:06	-23%
PM Peak	12:17	10:56	09:08	-26%

Table 4-36: Pre-construction vs. Post-construction Mean Speeds, Route 2

Route 2 – Mean Speeds (in kmph)				
Time Period	July 2005	August 2007	July 2008	% Change 2005-2008
AM Peak	21.86	24.82	25.96	19%
Inter-peak	24.43	28.2	27.74	14%
PM Peak	15.78	15.48	18.53	17%

It is evident from Table 4-35 and Table 4-36 that the average journey times on the SH1 network has experienced significant reductions for across all peak periods with an increase in mean travel speeds. However, Table 4-33 and Table 4-34 indicate average journey times have increased marginally post completion of the WICB. Mean speeds have also decreased between survey periods.

In summary, it was not possible to carry out a comparison of calculated travel time benefits as the calibrated and validated SATURN model including forecast year models) were not available at the time of this analysis. Moreover, the SATURN modelling carried out as part of this research project had various modelling issues which do not allow investigating the how much of the forecasted travel time benefits have been realised for the current traffic and network conditions. In order to better assess the overall performance of the WICB further modelling inputs and validation processes may be required on top of the work done in this study. It is noted that currently, Opus has been commissioned by WCC to update and validate the 2001 SATURN model to 2006 using the revalidated 2006 WTSM matrices. These works involve a robust validation process to reflect the current traffic conditions and traffic behaviour. The use of this updated SATURN model, following the validation process will give a much better indication of the performance of the WICB at the network level, allowing for a comparison of forecasted travel benefits against those realised.

4.4 Study Site 4 – Mana Esplanade Improvements

4.4.1 Pre-construction Analysis

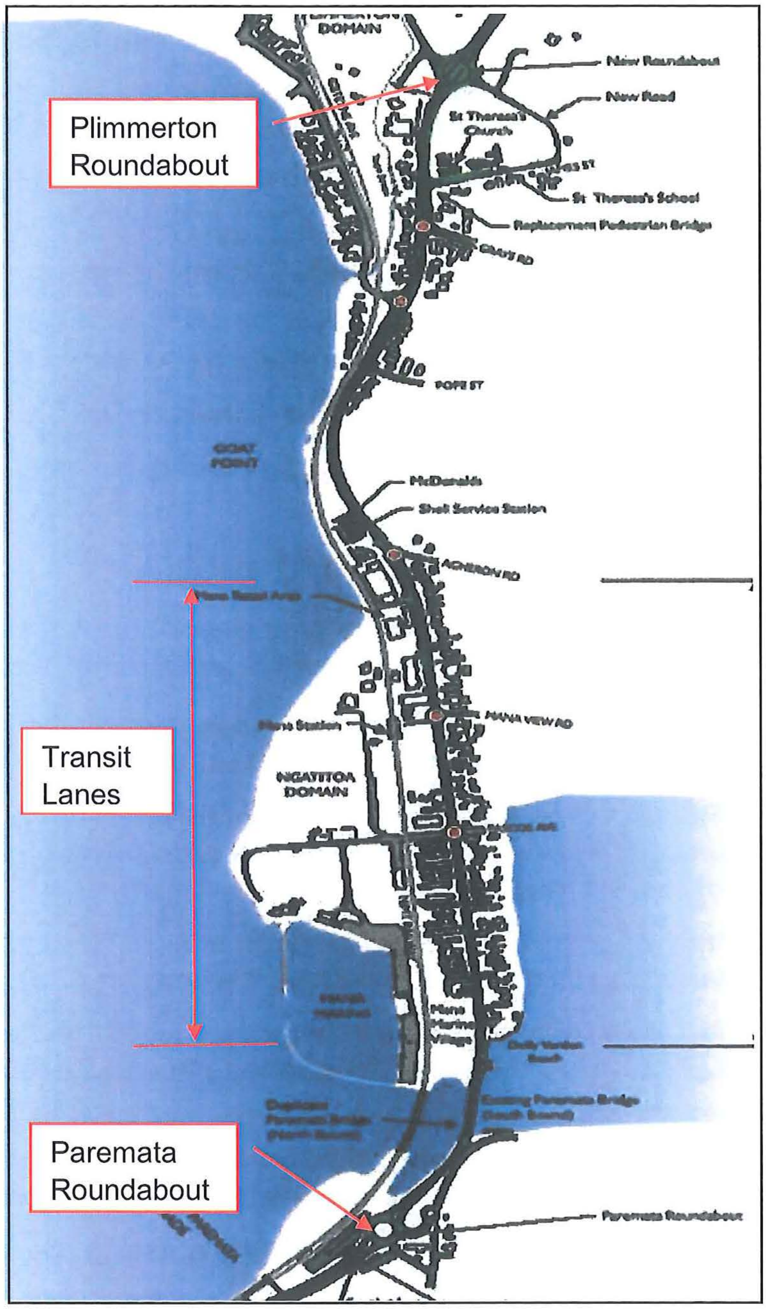
The Mana Esplanade Improvement project (part of the Parameta to Plimmerton upgrade) is located on SH1 between Paremata and Plimmerton and was implemented in 2005. Figure 4-18 Includes location of Study Site 4, Mana Esplanade Improvements.

The main features of the project included widening the highway from south of James street to the Paremata Bridge to provide for the new "T2" High Occupancy Vehicle (HOV) transit lanes and clearways and defined parking conditions. The improvements also included installation of five sets of traffic signals along St Andrews Road and Mana Esplanade.

Though the objective at the start of the research project was to include Study Site 4 in the analysis, it turned out to be near impossible task to get access to the Scheme Assessment Report and other traffic data used for the pre-construction economic appraisal. The author contacted various sources at NZTA to retrieve the SAR of the project from their central project library. However, the data was unavailable and the author was directed towards the Consultants. However, upon numerous contacts only a post construction review report was provided to the author a few weeks before the submission of this report. During the research study process, in the absence of relevant project data, the author had to guess/anticipate the surveys that could probably have been undertaken for the economic appraisal.

Given the above situation, this study site analysis only includes comparison of traffic data collected by the author and extracts of the data from various post construction travel behaviour reports supplied to the author.

Figure 4-18: Location of Study Site 4, Mana Esplanade Improvements



The preconstruction analysis (Beca, 2006) included traffic delay surveys carried out in 2003 at five different intersections along St Andrews road, prior to the installation of traffic signals at those intersections. The surveys included recording delay for only side road traffic either crossing or entering the state highway stream. The delays were recorded by recording the time vehicles enter a side road queue and the time they exit the intersection. The survey times for the surveys in 2003 were as follows:

- Weekday: 9:30am to 6:30pm
- Weekend: Saturday - 8:30am to 7:30pm and Sunday - 8:30am to 2:30pm

A summary of the recorded traffic delays on the side roads is included in Table 4-37

Table 4-37: Summary of recorded average delays on side roads (2003)

Intersection	Weekday average delay (seconds)	Saturday average delay (seconds)	Sunday average delay (seconds)
Pascoe (east)	5.5	5.6	3.2
Pascoe (west)	18.6	16.4	13.9
Mana View (east)	5.2	6.0	2.5
Mana View (west)	13.2	12.1	16.1
Acheron (east)	7.4	13.4	13.8
Acheron (west)	No data	No data	No data
Steyne Avenue	21.6	29.5	32.8
Grays Road	No data	3.9	3.2

Source: Beca (2006)

The pre-construction surveys also included travel time surveys and HOV surveys. The pre-construction travel time survey results included below refers to a route commencing at the Whitford Brown Avenue and Airlie Road along SH1. The travel time surveys were carried in 2003 and HOV surveys were carried out in February 2005. Table 4-38 and Table 4-39 include a summary of travel time and HOV surveys.

Table 4-38: Summary of travel time surveys (2003)

Direction	Weekday mean travel time (in minutes and seconds)	Saturday mean travel time (in minutes and seconds)	Sunday mean travel time (in minutes and seconds)
Northbound	0:09:01	0:13:12	0:07:02
Southbound	0:09:14	0:08:16	0:07:12

Source: Beca (2006)

Table 4-39: Summary of HOV Survey (2005)

Day/time	Direction	2005 Volumes	2005 % HOV
Weekday 6:30 – 9:30am	Southbound	3908	24.5%
Weekday 3:30 – 6:30pm	Northbound	4290	31.3%
Saturday 11:30 – 2:30pm	Northbound	3868	52.9%
Sunday 3:30 – 6:30pm	Southbound	3472	59.6%

Source: Beca (2006)

The recorded traffic volumes on SH1 near the project vicinity (SH1/1035/15.2, Paremata Bridge) are 29,910 vehicles per day (vpd) in 2003.

4.4.2 Post-construction Analysis

This section summarises the traffic survey data from post-construction travel behaviour report (Beca, 2006) and the traffic survey data collected by the author. The surveys carried out by the author only included side road delays and travel time surveys recorded between 16 December 2008 and 18 December 2008. The surveys were recorded for weekday AM Peak (7:30am to 8:30am) and weekday PM peak (4:30pm to 5:30pm) only. Please note the survey information included below.

Delay Surveys

The traffic delay surveys by the author included recording delay for only side road traffic either crossing or entering the state highway stream. The traffic delay survey method is based on the *General Traffic Equation: Flow-rate **q** (veh/hr) = density **k** (veh/km) × space-mean-speed **v** (km/hr)*

The method assumes that, if the actual traffic density (or concentration) is greater than the expected density (based on the flow-rate and an assumed uncongested space-mean *speed, then the there is evidence of traffic delay. The difference between the observed and expected density is a measure of the delay.*

Source: Koorey & Alan (2008)

The delay surveys were recorded for the side roads along St Andrews Road.

- Grays Rd East (Grays Rd / St Andrews Rd Intersection)
- Steyne Avenue West (Steyne Avenue West / St Andrews Rd Intersection)
- Pope St East (Pope St East / St Andrews Rd Intersection)
- Acheron Rd East (Acheron Rd East / St Andrews Rd Intersection)
- Mana View Rd East & West (Mana View Rd / St Andrews Rd Intersection)

Please note that a total of 60 samples were collected per each time period and per side road. A brief description of the survey methodology has been included in Appendix C of this report.

The 2006 post-construction delay surveys extracted from post-construction travel behaviour report (Beca, 2006) was based on recording the delay experienced by side road traffic either crossing or entering the state highway stream or turning right from the state highway traffic into the side road. These surveys were recorded every 10 seconds throughout the duration of the survey periods shown below.

- Wednesday 6 September 2006 - 7:00am to 10:00am, 12:00pm to 2:00pm and 4:00pm to 6:30pm
- Saturday 9 September 2006 - 10:00am to 4:00pm
- Sunday 10 September 2006 - 12:00pm to 7:00pm

Table 4-40 and Table 4-41 include a summary of side road delays recorded in 2008 and 2006 respectively.

Table 4-40: summary of Side road delays, 2008

Side Road	A.M. (7:30am - 8:30am) Average Delay in seconds (2008)	P.M. (4:30pm - 5:30pm) Average Delay in seconds (2008)	Average (2008)
Grays Rd East	43.6	43.6	43.6
Steyne Avenue West	40	49.3	44.6
Pope St East	19	28.1	23.5
Acheron Rd East	35	39	37
Mana View Rd East	40.5	69*	40.5**
Mana View Rd West	43	34.8	38.9

** Errors in the survey data sheets. Therefore, this data has been not included in analysis.*

*** Based on AM peak only*

Table 4-41: Summary of Side Road delays, 2006

Intersection	Weekday average delay (seconds)	Saturday average delay (seconds)	Sunday average delay (seconds)
Pascoe (east)	29.1	32.1	30.2
Pascoe (west)	34.0	36.5	38.4
Mana View (east)	30.7	32.7	28.0
Mana View (west)	32.0	39.0	33.0
Acheron (east)	30.2	31.2	29.0
Acheron (west)	26.7	31.5	27.5
Steyne Avenue	38.2	35.1	35.4
Grays Road	37.8	40.3	39.3

Source: Beca, 2006

Travel Time Surveys

The post-construction travel surveys were measured by using the floating car method and measured between Whitford Brown Avenue and Airlie Road along State Highway 1 (Beca, 2006). The surveys were recorded during the following periods:

- Thursday 17 August 2006 - 7:00am to 10:00am, 12:00pm to 2:00pm and 4:00pm to 6:30pm
- Saturday 19 August 2006 - 10:00am to 4:00pm
- Sunday 20 August 2006 - 12:00pm to 7:00pm

In addition, the carried out the travel time surveys between Paremata roundabout and Plimmerton roundabout. The surveys required two cars starting at the same time but one car using the T2/HOV lane throughout the survey period and another car using the normal traffic lane (or non-T2 lane). As noted earlier, the surveys were recorded for weekday AM Peak (7:30am to 8:30am) and weekday PM peak (4:30pm to 5:30pm) only.

A summary of 2006 surveys and 2008 surveys are included in Table 4-42 and Table 4-43 below.

Table 4-42: Summary of Travel Time Surveys, 2006

Direction	Weekday mean travel time (in minutes and seconds)	Saturday mean travel time (in minutes and seconds)	Sunday mean travel time (in minutes and seconds)
Northbound	0:07:01	0:07:22	0:07:02
Southbound	0:07:22	0:07:47	0:07:12

Source: Beca (2006)

Table 4-43: Summary of Travel Time Surveys (Author), 2008

Direction	Average Travel times AM		Average Travel times PM	
	T2	GT	T2	GT
A to I (Northbound)	00:03:49	00:04:10	00:03:56	00:04:12
J to R (Southbound)	00:03:50	00:04:15	00:05:55	00:05:60

Where:

A = Entering Paremata roundabout (after crossing the limit lines)

I = Exiting Plimmerton Roundabout

J = Entering Plimmerton roundabout (after crossing the limit lines)

R = Exiting Paremata Roundabout

T2 = Transit Lane/ High Occupancy Vehicle Lane

GT = General Traffic Lane

HOV Surveys

The Post-construction HOV surveys were recorded to compare the occupancy of T2/HOV lanes on SH1 with pre-construction occupancy. However, the surveys only included the counts of vehicles with two or more people in the vehicle using the left hand lane (i.e. T2 Lane) and right hand lane but did not include any traffic volumes as they were obtained from SCATS data (Beca, 2006).

The HOV surveys were carried out for the following time periods:

- Wednesday 6 September 2006 - 6:30am to 9:30am (southbound), 3:30pm to 6:30pm (northbound)
- Saturday 9 September 2006 - 11:30am to 2:30pm (northbound)
- Sunday 10 September 2006 - 3:30pm to 6:30pm (southbound)

A summary of HOV survey carried in September 2006 is included in Table 4-44

Table 4-44: Summary of HOV Survey, 2006

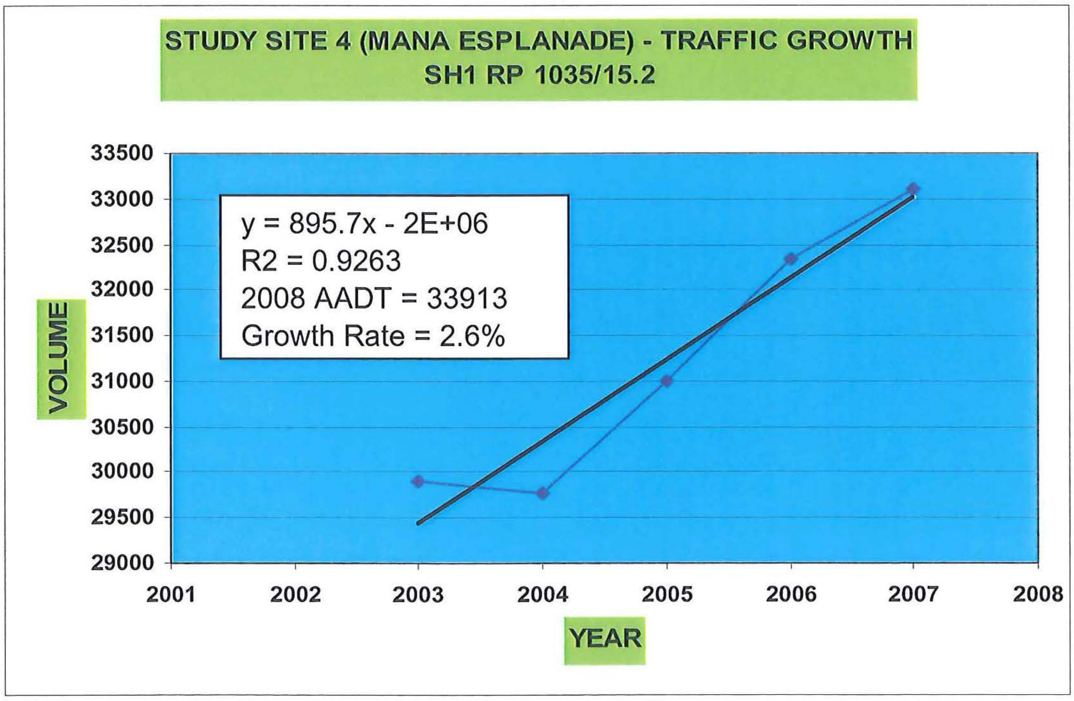
Day/time	Direction	2006 Volumes	2006 % HOV
Weekday 6:30 – 9:30am	Southbound	4,122	25.9%
Weekday 3:30 – 6:30pm	Northbound	4,519	30.0%
Saturday 11:30 – 2:30pm	Northbound	3,752	54.3%
Sunday 3:30 – 6:30pm	Southbound	3,586	66.3%

Source: Beca (2006)

Traffic volumes

As noted in Section 4.4.1, the recorded traffic volumes on SH1 near the project vicinity (SH1/1035/15.2, Paremata Bridge) are 29,910 vpd in 2003. However, the traffic flows have increased to approximately 31,000 vpd in 2005 and 33,100 in 2007 with growth rates of 2.6 % and predicted traffic flows of approx. 33,900vpd in 2008. The historical traffic volumes and calculated traffic growth is included in Figure 4-19.

Figure 4-19: Traffic Growth Rate at Mana Esplanade (Paremata Bridge)



4.4.3 Results and Discussion

As noted in section 4.1.1, in the absence of relevant project and traffic data, the author had to guess/anticipate the traffic surveys that probably have been undertaken for the economic appraisal of the project. This has led to differences in survey periods and survey methods. In light of this, it is not possible to neither make a direct comparison between pre-construction and post-construction survey results nor draw a conclusion with a certain degree of confidence. In the absence of economic appraisal data, a summary of different survey results of pre-construction and post-construction data have been included in this section with a brief commentary on the results. There are limitations to the use of these survey data and they should be borne in mind before any conclusions are drawn though a comparison of survey results.

As stated in section 4.4.2, the post-construction delay surveys were recorded in 2006 (Beca, 2006) and 2008 at five different intersections along St Andrews Road listed above. However, the 2006 surveys recorded delay experienced by side road traffic either crossing or entering the state highway stream or turning right from the state highway traffic into the side road. The pre-construction delay surveys recorded in 2003 (Beca, 2006) included only side road traffic either crossing or entering the state highway stream. The post-construction delays surveys recorded in 2008 recorded delays for side road traffic only either crossing or entering the state highway stream which is similar to the 2003 surveys. However, the 2008 (post-construction) survey methodology is different from the 2003 (pre-construction) and 2006 (post-construction) surveys and all the three surveys have been recorded at different time periods. As the survey data was not supplied to the author it was not even possible to extract the survey information for the overlapping time periods amongst all the three surveys and list them together.

Given the above situation, Table 4-45 summarises the delay survey results for side roads for only weekdays.

Table 4-45: Summary of pre-construction and post-construction delay survey results

Intersection	Pre-construction: 2003 - Weekday average delay (seconds)	Post-construction: 2006 - Weekday average delay (seconds)	Post-construction: 2008 - Weekday average delay (seconds)
Pascoe (east)	5.5	29.1	No data
Pascoe (west)	18.6	34.0	No data
Mana View (east)	5.2	30.7	40.5
Mana View (west)	13.2	32.0	38.9
Acheron (east)	7.4	30.2	37
Acheron (west)	No data	26.7	No data
Steyne Avenue	21.6	38.2	44.6
Grays Road	No data	37.8	43.6

Though a direct comparison between the survey results is not ideal, the magnitude of the delays indicates there has been a significant increase in average delays for the side roads.

Post-construction travel time versus pre-construction travel time surveys comparison conducted in 2006 and 2003 are included in Table 4-46. Also, a comparison of travel times surveys of vehicles using the general/mixed traffic lane vs. T2 lanes recorded in 2008 has been included in Table 4-47 below. In addition, traffic travel speeds using the GT lane vs. T2 lanes has also been included in Table 4-48.

It is evident from Table 4-46 that travel times have reduced post-construction during weekdays which constitutes the major portion of travel in a week. A significant decrease in travel times is noted for northbound traffic on Saturday peak periods. There has been a negligible increase in travel times on Sundays. On the other hand, Table 4-48 indicates there is benefit in using the T2 lanes as opposed to the general/mixed traffic lanes.

Table 4-46: Comparison of Pre-construction (2003) vs. Post-construction (2006) travel times

Time Period	Northbound			Southbound		
	Pre-const.	Post-const.	Change	Pre-const.	Post-const.	Change
Weekday	0:9:01	0:07:01	0:02:00	0:09:14	0:07:22	0:01:58
Saturday	0:13:12	0:07:22	0:05:30	0:08:16	0:07:47	0:00:29
Sunday	0:07:02	0:07:19	- 0:00:17	0:07:12	0:07:39	-0:00:27

Note: (+) indicates' decrease in travel time and (-ve) indicates increase in travel time.

Source: Beca (2006)

Table 4-47: Comparison of travel times using general traffic lane and T2 lane, 2008

Direction	Average Travel times AM			Average Travel times PM		
	GT	T2	Difference	GT	T2	Difference
Northbound	0:04:10	0:03:49	0:00:21	0:04:12	00:03:56	0:00:16
Southbound	0:04:15	0:03:50	0:00:25	0:05:60	0:05:55	0:00:05

Table 4-48: Calculated Travel speeds GT lane vs. T2 lane, 2008

Direction	AM Peak - Average Travel Speeds (kmph)			PM Peak - Average Travel Speeds (kmph)		
	GT	T2	Change	GT	T2	Difference
Northbound	40.3	44.03	+3.73	40.0	43.08	+3.08
Southbound	39.55	43.82	+4.27	28.0	28.4	+0.4

Note: (+) indicates' increase in speed' i.e. vehicles are travelling faster.

The results in Table 4-49 indicate that the overall southbound and northbound traffic volumes have increased in the weekdays with slight increase in percentage of HOV in southbound direction and a slight decrease in percentage of HOV. The Saturday survey results comparison indicates the northbound traffic volumes have increased but the percentage HOV has increased slightly. The Sunday survey results comparison indicates a biggest increase in percentage of HOV along with increase in total southbound traffic volumes. Overall there is a little increase in the percentage of HOV along SH1.

However, it should be noted that, the 2006 weekday survey results recorded about 731 HOV using T2 lanes compared with 338 HOV using the GT lane in northbound direction and 966 HOV using T2 lanes compared with 390 HOV using the GT lane in southbound direction. On the other hand, a greater number of HOV (922) were using GT lanes compared with the HOV (1455) on T2 lanes.

Table 4-49: Pre-construction (2005) vs. Post-construction (2006) HOV survey results

Day / time	Direction	2005 Volumes	2005 % HOV	2006 Volumes	2006 % HOV
Weekday 6:30-9:30am	Southbound	3,908	24.5%	4,122	25.9%
Weekday 3:30-6:60pm	Northbound	4,290	31.3%	4,519	30.0%
Saturday 11:30-2:30pm	Northbound	3,868	52.9%	3,752	54.3%
Sunday 3:30-6:30pm	Southbound	3,472	59.6%	3,586	66.3%

Source: Beca (2006)

In summary, the discussions carried out in this section indicate that side road delays may have increased notably compared with the pre-construction delays. The T2 lanes may have been successful in attracting HOV on to the T2 lanes however; the overall increase in % HOV is negligible. The travel time surveys indicated that there have been notable decreases in travel times on weekdays but the differential speeds between the HOV using T2 lanes and the normal traffic lanes is around 3km to 4km or time savings up to 30 seconds in travel time.

It is obvious that the primary objective of the HOV or T2 lane is to give a travel time advantage to higher occupancy vehicles and thus encouraging more people to travel efficiently by car pooling and combining the individual trips to occur at the same time. International literature indicates that travel time savings on successful facilities are often in the range of ½ to one minute per mile (or per 1.61 km). A heavily congested mixed lane (or GT lane) may cause vehicles on HOV lanes (or T2 lanes) to travel slower then they may otherwise because of side friction from the heavily congested mixed traffic flow (London, 2007). It is essential that a differential travel speed exists between the HOV/ T2 lanes and GT lanes in order to attract more HOV on to the network and provide travel time saving incentives for higher occupancy vehicles.

It is envisaged that vehicle occupancy forecasts, HOV forecast of usage of T2 lanes, travel time savings for the HOV and vehicles on the network are some of the parameters that could have been used for the economic appraisal of the project. It is not possible to determine the overall size of the post-construction benefits without knowing or having access to the pre-construction economic appraisal data, underlying assumptions, appraisal tools (e.g. traffic models) and the evaluation methodology adopted to determine scale of the forecasted travel benefits that have been realised.

The main issue identified in the analysis is the fact that the difficulties faced by the author to gain access to the project data and obtain relevant information to include in the analysis of this research project highlights the need for a central data base storage system for the projects in the region. This is absolutely essential if a programme such as POPE is implemented in New Zealand.

5 Conclusions

The fact that all the four identified case studies is analysed in a different way presents a challenge to find a common trend or issues in the forecasting of travel time benefits. Hence, consideration should be given to evaluating projects of similar nature and characteristics in a pool e.g. intersection improvement projects, bypass projects etc to identify common issues arising in the evaluation of travel time benefits. A POPE process as in UK would be extremely beneficial for New Zealand which would make the claims of efficient investment of rate payer's money more transparent for provision of transport infrastructure. By monitoring the performance of the transport infrastructure schemes it not only highlights the accuracy issues associated with the scheme appraisals but also help to identify any deficiencies in the evaluation process and provide an opportunity for potential improvements.

A major fundamental issue identified in this project is the actual timing and frequency with which the post-construction reviews should be carried out. The issues were evident from Case Study Site 4, Mungavin Intersection upgrade (Mungavin interchange) which was constructed about two decades ago, during which major network changes have occurred restricting the ability to quantify the size of travel benefits realised.

In addition, there are various other issues in a successful implementation of such a process. The issues may vary from simple reasons of absence of a centralised data base system of projects (which stores the related traffic data used in the pre-construction analysis) to the access to the various project economic appraisals. Though it is acknowledged that the most of the SAR includes relevant traffic information the fact that the author could not get access to the economic /project appraisal data hampering the ability to draw any conclusions for the research project highlights and supports the importance of this issue. In some cases there may be an element of sensitivity attached to getting access to data or release of project performance due to political reasons. However, this should not be a major obstacle in implementation of a process such as POPE if it is accepted that the public/tax payer's money deserves an efficient investment and a degree of transparency is required in all the evaluations of transport investment projects.

6 Recommendations for Future Research

Section 2 and Section 4 of this report has shown in general terms the issues associated for the diverse range of road improvement schemes projects. The discussions have pointed out the area which require further research the transport benefits, especially the travel time benefits are to be accurate and efficiently estimated. A brief description of the main areas for future research should include the following:

- A study comprising of selection of transport investment schemes with similar or common traffic characteristics e.g. bypass schemes should be selected and post-construction evaluation should be carried out to identity common issues and trends

- A study comprising of congestion reduction projects in the urban areas should be conducted using a network traffic model with variable demand matrix approach and fixed demand matrix approach.

- Evaluation of travel benefits across the network using trip based analysis should be carried with a prospect of introducing consumer surplus theory to evaluate the total travel time benefits as opposed to benefits determined by reduction of congestion on links.

- This study considered only the travel time benefits and did not take into account of other transport benefits or disbeenfits. Future analysis could include similar studies for other transport costs (e.g. vehicle operating costs, carbon emissions etc) such as the current research either independently or in conjunction with other transport benefits.

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Appendix A – Base Values of Travel Time (NZTA's EEM Data)

Table 1: Base values for vehicle occupant time in $/h (all road categories; all time periods – July 2002)

Vehicle occupant	**Work travel purpose**	**Commuting to/from work**	**Other non-work travel purposes**
Base values of time for uncongested traffic ($/h)			
Car, motorcycle driver	23.85	7.80	6.90
Car, motorcycle passenger	21.70	5.85	5.20
Light commercial driver	23.45	7.80	6.90
Light commercial passenger	21.70	5.85	5.20
Medium/heavy commercial driver	20.10	7.80	6.90
Medium/heavy commercial passenger	20.10	5.85	5.20
Seated bus and train passenger	21.70	4.70	3.05
Standing bus and train passenger	21.70	6.60	4.25
Pedestrian and cyclist	21.70	6.60	4.25
Maximum increment for congestion (CRV, $/h)			
Car, motorcycle driver	3.15		2.75
Car, motorcycle passenger	2.35		2.05
Commercial vehicle driver	3.15		2.75
Commercial vehicle passenger	2.35		2.05

Table 2: Base values for vehicle and freight time in $ / h (July 2002) for vehicles used for work purposes

Vehicle type	**Vehicle and freight time ($/h)**
Passenger car	0.50
Light commercial vehicle	1.70

Vehicle type	Vehicle and freight time ($/h)
Medium commercial vehicle	6.10
Heavy commercial vehicle I	17.10
Heavy commercial vehicle II	28.10
Bus	17.10

Table 3: Composite values of travel time in $ / h (all occupants and vehicle types combined – July 2002)

Road category and time period	Base value of time ($ / h)	Maximum increments for congestion (CRV $ / h)
Urban arterial		
Morning commuter peak	15.13	3.88
Daytime inter-peak	17.95	3.60
Afternoon commuter peak	14.96	3.79
Evening/night-time	14.93	3.68
Weekday all periods	16.83	3.79
Weekday/holiday	14.09	4.26
All periods	16.27	3.95
Urban other		
Weekday	16.89	3.82
Weekday/holiday	14.10	4.32
All periods	16.23	3.98
Rural strategic		
Weekday	25.34	4.23
Weekend/holiday	19.21	5.22
All periods	23.25	4.39
Rural other		
Weekday	24.84	4.24
Weekend/holiday	18.59	5.23
All periods	22.72	4.40

Appendix B - Example of POPE Report Structure

Executive Summary

This section gives an overview of the project/scheme mainly describing the start, type, problems "Before Start", solutions "After Start" of the project. The following bullet points will give an idea about the sub-structure of this section

- Project Description: Proposed Length of Section, Single Carriageway or Dual Carriageway, Existing Road description etc.
- Start date of Project
- Effects of the new scheme after opening
- Include Index map of the scheme/project
- Discuss main effects of scheme after opening of project e.g. journey time savings, route stress, benefits, environment etc.

1. Introduction

1.1 Background

In this section the above points are discussed in detail.

1.2 Scheme Objectives

Describe the scheme objectives and reasons for why the scheme was undertaken.

1.3 Purpose of the Report

1.4 Report Format

Following the introduction, discuss the structure for the rest of the report e.g.

Section XXX discusses the safety aspects of the scheme

Section YYY outlines the economic aspects

2. Safety

2.1 Introduction

This section looks at the change in accident rates since opening of the bypass, via the COBA (BCR analysis in NZ) method and through actual data collection

2.2 Data Collection

2.3 Accident Data

2.4 Pope Methodology

2.5 Changes in Accident Benefits

With the help of table show the difference between the actual number of accidents before and after opening of the bypass and the difference between the numbers predicted by COBA.

For example:

Table- Comparison of actual and predicted number of accidents along the section & links

Average Number of accidents per year			
		Low Growth	*High Growth*
OPR COBA	*Do Minimum*	*17*	*19*
	Do Something	*7*	*8*
	Saving (reduction)	*10 (59%)*	*11 (58%)*
Actual	*'Before'*	*18*	*18*
	'After'	*4*	*4*
	Saving (reduction)	*14 (78%)*	*14 (78%)*

2.6 Summary of Results

3. Economy

3.1 Introduction

Economic benefits of a scheme assessed traditionally, which considers changes in :

- Link transit time, which is the time on each affected link both before and after opening weighted by vehicle flows;
- Vehicle operating costs (VOC), reflecting fuel and other operating costs calculated by a change in total distance travelled on the affected links, but also considering vehicle speeds; and
- Accident rates and costs, which change after infrastructure improvements

This section presents a comparison of predicted benefits as calculated by COBA and an assessment of what those benefits would be if the outturn traffic volumes and journey time savings were known at the time, followed by a summary of the results obtained from the surveys that were conducted.

3.2 Data Collection

Mention the survey data type including details.

For example:

Before surveys

Traffic Impact Study (TIS) 'After' Survey

One-year 'After' Survey

Journey Time Survey

3.3 Pope Methodology

This section assesses the level of economic benefits predicted for the scheme and compares these predictions with actual benefits accrued when considering actual traffic volume changes and actual journey time benefits.

The approach taken is termed the Post Opening Project Evaluation (POPE) methodology.

3.4 Vehicle Hour Benefits

To calculate link transit time or vehicle hour benefits, the COBA / BCR deck from pre construction appraisal must be available, and the following changes implemented so that sensible and like-for-like comparisons can be made:

- Pre Construction – Do Minimum: Although flow and delay data would have been probably collected prior to scheme implementation journey time and delay information must be determined by re-running the COBA deck with a journey time year set to the same as that when the Post Opening surveys were undertaken;
- OPR – Do Something: As with the Pre Construction - Do Minimum this data will need to be determined from re-running the COBA / BCR deck for the survey year after opening;
- Actual – Do Minimum: Pre opening count and Journey Time data is collected for each new scheme route before opening. This information is obtained for the AM, IP, PM etc time periods; and
- Actual – Do Something: Traffic volumes and journey times from surveys after the opening of the schemes are directly applicable to this scenario.

3.5 Changes in Link Transit Time

With the help of tables show the difference between the vehicle hours before and after opening of the scheme (observed traffic volumes multiplied by journey times) and the differences between flow x times for the same links in the Pre construction COBA / BCR.

Example for Tables to be used in this section

- *Comparison of Vehicle hours*
- *Link Transit Time Benefits*
- *Comparison of POPE Outturn and Predicted Link Transit Benefits*

3.6 Predicted vs. Actual Flow

Use Table *Comparison of Predicted and Actual Flows* to highlight flow patterns.

3.7 COBA / BCR Re-evaluation

Use following tables in this section to highlight the level of benefits that were predicted for the scheme:

- Present Value of Benefits at low growth
- Present Value of Benefits at high growth
- Comparison of Weighted Economic Benefits

3.8 Comparison of POPE and COBA Methodology

In this section highlight points on your findings using both methodologies.

Use tables for comparing results.

3.9 Re-Evaluation of Scheme Costs

In this section predicted cost and actual Cost for the scheme are compared.

3.10 Summary of Results

3.11 Journey Times

This section basically highlights the time savings after opening of the scheme. However journey speeds and route stress can be discussed in the section.

3.12 Summary of POPE Methodology

4. Environment

4.1 Introduction

Environmental sub-objectives to be evaluated in accordance with the methodology for Post Opening Project Evaluations - Environment (POPE-E). The purpose of including the Environmental sub-objectives in POPE is to expand the role of after-opening evaluation for road schemes.

4.2 Data collection

The Data Collection process consisted of four main stages:

- Obtaining and Analysing Data;
- Conducting Site Inspections;
- Undertaking Consultations with the Statutory consultees; and
- Liaising with the RCA including Project Sponsor.

4.3 Methodology

4.4 Evaluation

Assessment of Sub-objectives. For example Noise, Air Quality, Landscape, Biodiversity, Heritage, and Water

Evaluations of these sub-objectives are discussed in this section

4.5 Evaluation Summary

5. Accessibility & Integration

5.1 Introduction
5.2 Data Collection
5.3 Methodology
5.4 Evaluation
5.5 Accessibility
5.6 Public Transport
5.7 Severance
5.8 Pedestrians and others
5.9 Integration
5.10 Evaluation Summary

6. Evaluation Summary table

6.1 Introduction
6.2 Appraisal Summary Table (AST)
6.3 Outturn Effects

7. Conclusion

8. Appendices

Appendix C – Traffic Survey Data Methodology Data collection Notes for Study Site 4

ENTR615 - Transport Network Modelling (2008)

TRAFFIC QUEUING & DELAY ESTIMATION

Background Theory

Estimation of traffic delay and queue lengths can be done using the "queue length" method, which is generally used at intersections but can be used to estimate the delay experienced by users of any section of road.

Note: Only traffic approaching the intersection is to be observed for the purposes of this survey; departing traffic can be ignored.

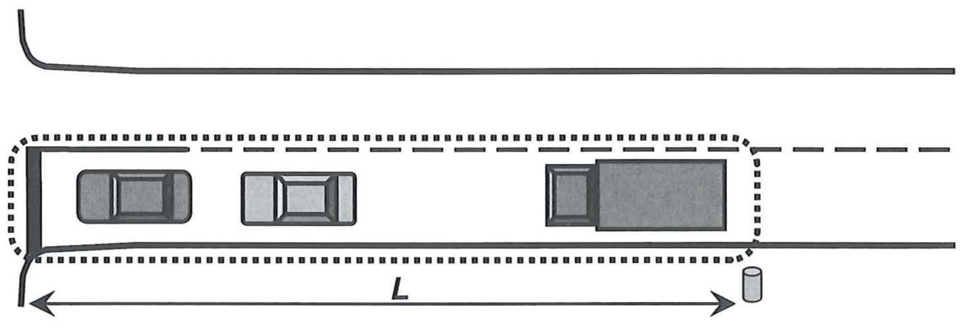
The method is based on the ***General Traffic Equation:***

*Flow-rate **q** (veh/hr) = density **k** (veh/km) × space-mean-speed **v** (km/hr)*

The method assumes that, if the actual traffic density (or "concentration") is greater than the expected density (based on the flow-rate and an assumed uncongested space-mean speed), then there is evidence of traffic delay. The difference between the *observed* and *expected* density is a measure of the delay.

The method normally requires at least two observers (but can be done with one);

1. One person counts the total number of vehicles, ***c***, passing a fixed length of roadway over a given time period ***T*** (i.e. observes the flow-rate, ***q*** = ***c/T***); *(a simple hand-written tally count will suffice, or use a clicker-counter)*
2. One person counts, at regular or random intervals, the instantaneous number of vehicles (moving or stopped), ***n***, in that fixed length of roadway (i.e. a "snapshot"). *(you will probably need some practice beforehand to be able to quickly count the correct number of vehicles)*



The interval between counts of the vehicles in the queue must be such that resonance with the frequency of an upstream traffic control (e.g. signals) is avoided; if in doubt use random time intervals. The time interval is typically in the range 15-60s.

Note: A pre-programmed Psion handheld organiser (available from UC) can be used to help provide accurate interval timings and store the resulting data.

Where queuing occurs (e.g. an intersection approach), the **length of roadway (*L*)** being observed should generally contain the whole queue. If there are occasionally queued vehicles <u>beyond</u> the chosen length of roadway, they should be included in the count (i.e. they would *like* to be inside the roadway length).

Note: Make sure that the boundaries of your study length are clearly identified; in some cases there are multiple lanes to count. You may need to make snap-judgement calls about whether a vehicle is "in" or "out" of this area – agree on a consistent approach to this.

The delay estimation procedure for each approach is:

1. Calculate the **average number of vehicles ($\underline{n}$)** in the study length at any given time; this is simply the average of the observed queue-length counts (***n***) over the survey duration.
2. Calculate the **expected number of vehicles (*e*)** in the study length if there is no delay and vehicles are able to travel at the **uncongested speed (*v*)**:

$$e = q \times L / v$$

   where ***q* = the flow-rate of vehicles** traversing the section during the **survey duration (*T*)**.

3. Calculate the **total traffic delay *d*** for the approach:

$$d = (\underline{n} - e) \times T$$

   and the **average delay** for vehicles on the approach is $[d / (q.T)]$.

The total intersection delay is the sum of the approach delays, while the average delay for the intersection is a flow-weighted average of the delays for the approaches.

Note: When doing your calculations, it is important that you ensure that your units (distance, time, etc) are compatible between the various parameters to be determined. As another check, it is worth considering whether the magnitude of your final average delay seems about right; often they are in the order of 10-30 s/vehicle.

To determine the **95th percentile queue length**, sort the observed queue-length counts (***n***) in descending order. Determine the queue-length value that is 5% along this list, e.g. with 200 observations, this would be the 10th highest count. This is the queue length that will not be exceeded 95% of the time.

Survey Procedure

(1) Select your approach leg and determine a suitable section length ***L*** (say ~50m) leading up to the intersection (easier to do if there is some identifiable feature at the boundary point). If vehicles *outside* of the section length are stopped in a queue (not just slowing down) count them too.

(2) For ***constant*** interval observations, record approach queue-length counts (***n***) using a handheld Psion device or manual survey sheet. Ideally, record at least **50 observations** with a fixed interval of **15-60 seconds** between each one.

(3) Separately record the ***volume count*** (***c***), i.e. manually count the number of individual motor vehicles (not cyclists) crossing the study length during the time between when the constant interval observations start and finish.

(4) With the resulting data, estimate the **total and average approach delay** and **95%^{ile} queue length** for the survey period, using the method described in the previous section. For urban 50 km/h areas, normally assume an estimated free (uncongested) speed, ***v***, of ~55 km/h.

(5) Compare the observed results (i.e. estimates of delay) between different times of the day, and also with any traffic model of the situation.

Mana View Rd East (Mana View Rd/ St Andrews Rd Intersection) Survey:

The Data Collection project will take place on Wednesday 18 Dec 2008 (weather permitting).

You should study these notes carefully on or before the count day so that you can become very familiar with all of the survey tasks.

Please ensure that you arrive on site at least fifteen minutes before the survey start time for the AM peak surveys and five minutes before the start time for the PM Peak.

When you arrive on site:

- Check that you have been given the correct equipment and/or survey forms
- Write your name on any forms in the space provided
- **Check your watch against the supervisor's time and note both times on the** form i.e. your time and the supervisors time.
- When you have finished each task, please pass the equipment back to the Supervisor. Equipment and survey forms are needed for data processing later on. Please note the forms should be left with the Supervisor
- If you are unsure of any observation please circle the affected value(s). At the conclusion of the survey write any notes on the back of the sheet to explain why you where unsure about an observation. This will assist us in correcting the survey if necessary.

Be exactly sure about any times you record (i.e. if you are late to arrive on site or if you were absent from the survey during any recorded period). If we know that there are errors, we can allow for them, otherwise the whole survey may need to be re-done at great expense because cross-checks on the data will show up inconsistencies

GENERAL NOTES:

This is a group effort. Some tasks rely on each other to produce a complete data set. Any "gaps" in the data will reduce (or destroy) the value of the survey. Also, please remember to be polite to any members of the public. **Do not obstruct footpaths.** If you are asked what you are doing, say it is a "Traffic Survey". It is nothing to do with the Police.

If it rains please keep your data sheets dry (each Supervisor has cling film available) but carry on collecting data in the rain unless the Supervisor tells you to stop.

Call your supervisor if you need to be relieved for a while for a toilet break or otherwise.

Bring suitable clothes and dress appropriately for the climatic conditions.

SAFETY IS THE MAIN PRIORITY. No enumerator will be required to work on the roadway, if you are required to cross roads in order to move between survey locations, please, *take the utmost care. Do not rush even if you fear being late.*

INSTRUCTIONS FOR EACH SURVEY

- Only **traffic approaching the intersection is to be observed** for the purpose of this survey; **departing traffic should be ignored**.
- The survey timings are 7:30 am to 8:30am in the morning and 4:30pm to 5:30pm in the evening.
- Each Surveyor will be assigned either a queue length count task or a volume count task.
- Depending on the task assigned, follow the instructions and record the data accordingly.
- The survey has to be done in pairs. I.e. Surveyor 1 and Surveyor 2 form a team and they record the data with time synchronisation and co-ordination.
- You will be provided with a clipboard with tally sheets. Use the tally sheets and record the data for the task you have been assigned

Survey Task:

Surveyor # 1 : Task - Queue Length Counts

Surveyor #1 will count the queueing that occurs on the length of the road way (50m box).

You will be recording all the vehicles stopped within the 50m box at every 60 second interval. If there are queued vehicles beyond the chosen length of the road way (50m) then they should be included in the count separately in the column provided on the tally sheets.

Note: Make sure that your boundaries of the study length (50m as indicated) are clearly identified; in some cases there are multiple lanes to count. You may need to make snap-judgement calls about whether the vehicle is in or out of this area – agree on a consistent approach.

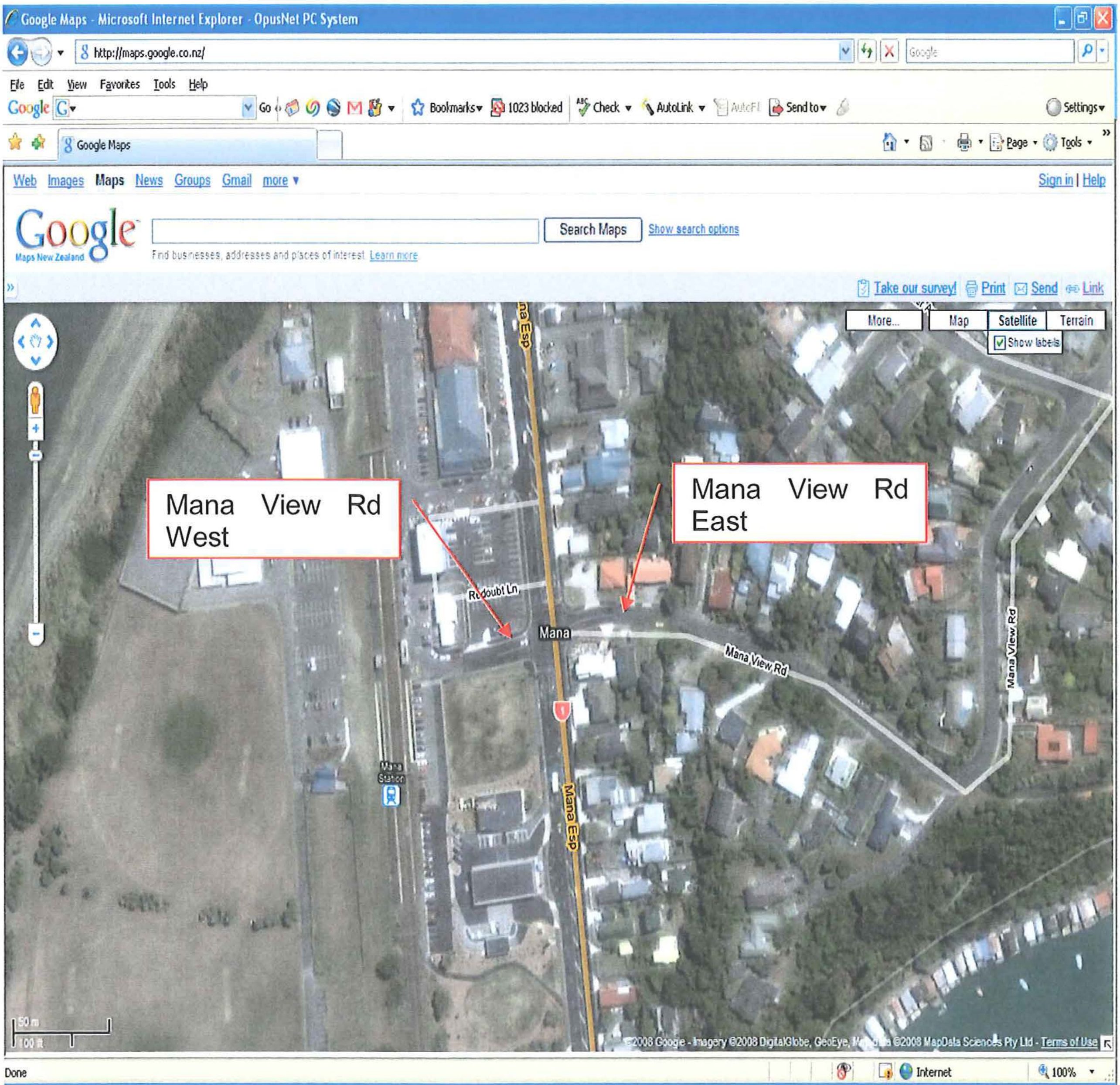
Surveyor # 2: Task – Traffic volume counts

Surveyor #2 will count the total number of vehicles passing a fixed point on the road way (say limit lines at the intersection or you being the reference point and the vehicles crossing in front of you) between the start and finish of the 60 second time interval set by the surveyor #1. As indicated on the tally sheets where required, irrespective of turning movement you can count all the traffic on that approach. In some cases, as indicated on the tally sheet you will be required to differentiate the traffic count (for example through movement and right turn separately).

Survey procedure:

1. Go to your assigned approach leg and try to relate the extent of 50m marked section length (see attached map) on the intersection approach by visual inspection. Though, note that the Surveyor #2 has nothing to do with the 50m mark. as Surveyor #2 is only required to count the traffic.

2. Surveyor #1 should call out "START" (indicating the start of the 60 second interval). From this point, surveyor #2 will start recording the volume counts (for the ease of counting, clickers are provided).
3. At the end of the 60 second interval Surveyor #1 should call out "Stop" indicating the end of the 60 second interval. At this point, Surveyor # 2 should note the total volume count recorded using the clickers. At the same time i.e. at the call out of "Stop" Surveyor #1 himself will have to carry out his task of recording the queue length task assigned to him i.e. recording the queue lengths observed at that point in time.
4. Repeat steps 2 and 3 and record the data at 60 sec interval for the full one hour period.



If you have any questions or queries call Kesh on 021 1067288 or (04) 4733157

Appendix D: Traffic survey Data Summary - Study Site 1

(Example Study Site 1)

Kaitoke to Temarua Realighnment - Summary of Speed Survey

PM Peak

	Car				HCV				Bus			
	NB		SB		NB		SB		NB		SB	
	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane
Run 1	84	79	89	94	76	57	78	92			71	76
Run 2	84	75	93	97	50	39	74	81				
Run 3	89	79	76	82			82	89				
Run 4	94	91					92	96				
Run 5	88	81					84	90				
Run 6	87	87					85	91				
Run 7	86	80										
Average Speed	87	82	86	91	63	48	81	88				

AM Peak

	Car				HCV				Bus			
	NB		SB		NB		SB		NB		SB	
	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane
Run 1	86	74	93	97	85	78	78	75	52	27	71	93
Run 2	86	80	86	89	57	27	81	90				
Run 3	86	86	94	96	69	46	72	89				
Run 4	89	80	99	100	75	58						
Run 5			97	100								
Run 6			95	96								
Average Speed	87	80	94	96	68	47	76	87				

Inter Peak

	Car				HCV				Bus			
	NB		SB		NB		SB		NB		SB	
	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane
Run 1	84	75	79	83	54	42	52	53	62	35		
Run 2	86	75			61	36	64	60				
Run 3							75	75				
Run 4							78	76				
Average Speed	85	75	79	83	59	37	68	66				

AVERAGE FOR FULL DAY

	Car				HCV			
	NB		SB		NB		SB	
	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane	Total Length	Passing Lane
Average Speed	86	79	86	90	63	44	75	80

Appendix E: Travel Time Benefit Calculations – Study Site 1

(Example Study Site 1)

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TRAVEL TIME COSTS SCENARIO A WORKSHEET A4.1

Option (1)	Road Section / Movement (2)	Time Period (3)	Time Periods per Year (4)	Vehicle Category (5)	Vehicles per Time Period (6)	Total Travel Time (min) (7)	Travel Time Cost ($/hour) (8)	Total Cost per Year ($) (9)		
DO MINIMUM				AADT =	5044					
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	1942	5.703	17.45	$1,175,597	342.2	$17.45
			"	LCV	227	5.703	22.71	$178,797	342.2	$22.71
			"	MCV	126	6.862	23.36	$122,946	411.7	$23.36
			"	HCV-I	101	6.862	32.86	$138,364	411.7	$32.86
			"	HCV-II	126	6.862	42.36	$222,963	411.7	$42.36
Northbound	Total	Days	365	Car	1942	5.957	17.45	$1,228,031	357.4	$17.45
			"	LCV	227	5.957	22.71	$186,772	357.4	$22.71
			"	MCV	126	8.489	23.36	$152,094	509.3	$23.36
			"	HCV-I	101	8.489	32.86	$171,166	509.3	$32.86
			"	HCV-II	126	8.489	42.36	$275,821	509.3	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$3,044,238**		
		($1175597 + $178797 + $122946) + ($1228031 + $186772 + $152094) =								
Annual Cost	=	(HCV-II, HCV-II)						**$808,314**		
		($138364 + $222963) + ($171166 + $275821) =								
REALIGNMENT OPTIONS				AADT =	5044					
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	1942	3.963	17.45	$816,863	237.8	$17.45
			"	LCV	227	3.963	22.71	$124,237	237.8	$22.71
			"	MCV	126	4.544	23.36	$81,413	272.6	$23.36
			"	HCV-I	101	4.544	32.86	$91,622	272.6	$32.86
			"	HCV-II	126	4.544	42.36	$147,642	272.6	$42.36
Northbound	Total	Days	365	Car	1942	3.963	17.45	$816,863	237.8	$17.45
			"	LCV	227	3.963	22.71	$124,237	237.8	$22.71
			"	MCV	126	5.410	23.36	$96,920	324.6	$23.36
			"	HCV-I	101	5.410	32.86	$109,074	324.6	$32.86
			"	HCV-II	126	5.410	42.36	$175,764	324.6	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$2,060,533**		
		($816863 + $124237 + $81413) + ($816863 + $124237 + $96920) =								
Annual Cost	=	(HCV-II, HCV-II)						**$524,102**		
		($91622 + $147642) + ($109074 + $175764) =								

DO MINIMUM				AADT =	5464	(Yr 2)				
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2082	5.703	17.45	$1,260,386	342.2	$17.45
			"	LCV	243	5.703	22.71	$191,417	342.2	$22.71
			"	MCV	135	6.862	23.36	$131,624	411.7	$23.36
			"	HCV-I	121	6.862	32.86	$165,960	411.7	$32.86
			"	HCV-II	151	6.862	42.36	$266,990	411.7	$42.36
Northbound	Total	Days	365	Car	2082	5.957	17.45	$1,316,601	357.4	$17.45
			"	LCV	243	5.957	22.71	$199,954	357.4	$22.71
			"	MCV	135	8.489	23.36	$162,828	509.3	$23.36
			"	HCV-I	121	8.489	32.86	$205,304	509.3	$32.86
			"	HCV-II	151	8.489	42.36	$330,285	509.3	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$3,262,810**		
		($1260386 + $191417 + $131624) + ($1316601 + $199954 + $162828) =								
Annual Cost	=	(HCV-II, HCV-II)						**$968,539**		
		($165960 + $266990) + ($205304 + $330285) =								
REALIGNMENT OPTIONS				AADT =	5464	(Yr 2)				
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2082	3.963	17.45	$875,778	237.8	$17.45
			"	LCV	243	3.963	22.71	$133,006	237.8	$22.71
			"	MCV	135	4.544	23.36	$87,159	272.6	$23.36
			"	HCV-I	121	4.544	32.86	$109,896	272.6	$32.86
			"	HCV-II	151	4.544	42.36	$176,796	272.6	$42.36
Northbound	Total	Days	365	Car	2082	3.963	17.45	$875,778	237.8	$17.45
			"	LCV	243	3.963	22.71	$133,006	237.8	$22.71
			"	MCV	135	5.410	23.36	$103,761	324.6	$23.36
			"	HCV-I	121	5.410	32.86	$130,828	324.6	$32.86
			"	HCV-II	151	5.410	42.36	$210,471	324.6	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$2,208,487**		
		($875778 + $133006 + $87159) + ($875778 + $133006 + $103761) =								
Annual Cost	=	(HCV-II, HCV-II)						**$627,990**		
		($109896 + $176796) + ($130828 + $210471) =								

TRAVEL TIME COSTS SCENARIO B WORKSHEET A4.1

Option	Road Section / Movement	Time Period	Time Periods per Year	Vehicle Category	Vehicles per Time Period	Total Travel Time (min)	Travel Time Cost ($/hour)	Total Cost per Year ($)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)			
DO MINIMUM				AADT =	5044						
									TT (sec)	TT ($/hr)	Check
Southbound	Total	Days	365	Car	2320	5.703	17.45	$1,404,610	342.2	$17.45	1404610
			"	LCV	76	5.703	22.71	$59,599	342.2	$22.71	59599.1
			"	MCV	76	6.862	23.36	$73,768	411.7	$23.36	73767.9
			"	HCV-I	25	6.862	32.86	$34,591	411.7	$32.86	34590.9
			"	HCV-II	25	6.862	42.36	$44,593	411.7	$42.36	44592.6
Northbound	Total	Days	365	Car	2320	5.957	17.45	$1,467,258	357.4	$17.45	1467258
			"	LCV	76	5.957	22.71	$62,257	357.4	$22.71	62257.4
			"	MCV	76	8.489	23.36	$91,256	509.3	$23.36	91256.2
			"	HCV-I	25	8.489	32.86	$42,791	509.3	$32.86	42791.5
			"	HCV-II	25	8.489	42.36	$55,164	509.3	$42.36	55164.2
Annual Cost	=	(Car, LVC, MCV)						**$3,158,748**			
		($1404610 + $59599 + $73768) + ($1467258 + $62257 + $91256) =									
Annual Cost	=	(HCV-II, HCV-II)						**$177,139**			
		($34591 + $44593) + ($42791 + $55164) =									
REALIGNMENT OPTIONS				AADT =	5044						
									TT (sec)	TT ($/hr)	Check
Southbound	Total	Days	365	Car	2320	4.151	17.45	$1,022,305	249.1	$17.45	1022305
			"	LCV	76	4.151	22.71	$43,378	249.1	$22.71	43377.5
			"	MCV	76	5.075	23.36	$54,554	304.5	$23.36	54553.5
			"	HCV-I	25	5.075	32.86	$25,581	304.5	$32.86	25581
			"	HCV-II	25	5.075	42.36	$32,978	304.5	$42.36	32977.5
Northbound	Total	Days	365	Car	2320	4.151	17.45	$1,022,305	249.1	$17.45	1022305
			"	LCV	76	4.151	22.71	$43,378	249.1	$22.71	43377.5
			"	MCV	76	7.889	23.36	$84,808	473.4	$23.36	84808.2
			"	HCV-I	25	7.889	32.86	$39,768	473.4	$32.86	39767.9
			"	HCV-II	25	7.889	42.36	$51,266	473.4	$42.36	51266.5
Annual Cost	=	(Car, LVC, MCV)						**$2,270,726**			
		($1022305 + $43378 + $54554) + ($1022305 + $43378 + $84808) =									
Annual Cost	=	(HCV-II, HCV-II)						**$149,593**			
		($25581 + $32978) + ($39768 + $51266) =									

DO MINIMUM				AADT =	5464	(Yr 2)					
									TT (sec)	TT ($/hr)	Check
Southbound	Total	Days	365	Car	2487	5.703	17.45	$1,505,562	342.2	$17.45	1505562
			"	LCV	81	5.703	22.71	$63,806	342.2	$22.71	63805.6
			"	MCV	81	6.862	23.36	$78,974	411.7	$23.36	78974.3
			"	HCV-I	30	6.862	32.86	$41,147	411.7	$32.86	41147
			"	HCV-II	30	6.862	42.36	$53,044	411.7	$42.36	53044.3
Northbound	Total	Days	365	Car	2487	5.957	17.45	$1,572,713	357.4	$17.45	1572713
			"	LCV	81	5.957	22.71	$66,651	357.4	$22.71	66651.4
			"	MCV	81	8.489	23.36	$97,697	509.3	$23.36	97696.9
			"	HCV-I	30	8.489	32.86	$50,902	509.3	$32.86	50901.8
			"	HCV-II	30	8.489	42.36	$65,620	509.3	$42.36	65619.6
Annual Cost	=	(Car, LVC, MCV)						**$3,385,403**			
		($1505562 + $63806 + $78974) + ($1572713 + $66651 + $97697) =									
Annual Cost	=	(HCV-II, HCV-II)						**$210,713**			
		($41147 + $53044) + ($50902 + $65620) =									
REALIGNMENT OPTIONS				AADT =	5464	(Yr 2)					
									TT (sec)	TT ($/hr)	Check
Southbound	Total	Days	365	Car	2487	4.151	17.45	$1,095,780	249.1	$17.45	1095780
			"	LCV	81	4.151	22.71	$46,439	249.1	$22.71	46439.1
			"	MCV	81	5.075	23.36	$58,404	304.5	$23.36	58403.9
			"	HCV-I	30	5.075	32.86	$30,429	304.5	$32.86	30429.4
			"	HCV-II	30	5.075	42.36	$39,228	304.5	$42.36	39227.8
Northbound	Total	Days	365	Car	2487	4.151	17.45	$1,095,780	249.1	$17.45	1095780
			"	LCV	81	4.151	22.71	$46,439	249.1	$22.71	46439.1
			"	MCV	81	7.889	23.36	$90,794	473.4	$23.36	90793.9
			"	HCV-I	30	7.889	32.86	$47,305	473.4	$32.86	47305.2
			"	HCV-II	30	7.889	42.36	$60,983	473.4	$42.36	60983.1
Annual Cost	=	(Car, LVC, MCV)						**$2,433,635**			
		($1095780 + $46439 + $58404) + ($1095780 + $46439 + $90794) =									
Annual Cost	=	(HCV-II, HCV-II)						**$177,946**			
		($30429 + $39228) + ($47305 + $60983) =									

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TRAVEL TIME COSTS Scenario A and B WORKSHEET A4.1

Option	Road Section / Movement	Time Period	Time Periods per Year	Vehicle Category	Vehicles per Time Period	Total Travel Time (min)	Travel Time Cost ($/hour)	Total Cost per Year ($)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		
DO MINIMUM				AADT =	5044					
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2320	5.703	17.45	$1,404,610	342.2	$17.45
			"	LCV	76	5.703	22.71	$59,599	342.2	$22.71
			"	MCV	76	6.862	23.36	$73,768	411.7	$23.36
			"	HCV-I	25	6.862	32.86	$34,591	411.7	$32.86
			"	HCV-II	25	6.862	42.36	$44,593	411.7	$42.36
Northbound	Total	Days	365	Car	2320	5.957	17.45	$1,467,258	357.4	$17.45
			"	LCV	76	5.957	22.71	$62,257	357.4	$22.71
			"	MCV	76	8.489	23.36	$91,256	509.3	$23.36
			"	HCV-I	25	8.489	32.86	$42,791	509.3	$32.86
			"	HCV-II	25	8.489	42.36	$55,164	509.3	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$3,158,748**		
		($1404610 + $59599 + $73768) + ($1467258 + $62257 + $91256) =								
Annual Cost	=	(HCV-II, HCV-II)						**$177,139**		
		($34591 + $44593) + ($42791 + $55164) =								
REALIGNMENT OPTIONS				AADT =	5044					
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2320	3.963	17.45	$975,992	237.8	$17.45
			"	LCV	76	3.963	22.71	$41,412	237.8	$22.71
			"	MCV	76	4.544	23.36	$48,848	272.6	$23.36
			"	HCV-I	25	4.544	32.86	$22,905	272.6	$32.86
			"	HCV-II	25	4.544	42.36	$29,528	272.6	$42.36
Northbound	Total	Days	365	Car	2320	3.963	17.45	$975,992	237.8	$17.45
			"	LCV	76	3.963	22.71	$41,412	237.8	$22.71
			"	MCV	76	5.410	23.36	$58,152	324.6	$23.36
			"	HCV-I	25	5.410	32.86	$27,268	324.6	$32.86
			"	HCV-II	25	5.410	42.36	$35,153	324.6	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$2,141,808**		
		($975992 + $41412 + $48848) + ($975992 + $41412 + $58152) =								
Annual Cost	=	(HCV-II, HCV-II)						**$114,855**		
		($22905 + $29528) + ($27268 + $35153) =								

DO MINIMUM				AADT =	5464	(Yr 2)				
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2487	5.703	17.45	$1,505,562	342.2	$17.45
			"	LCV	81	5.703	22.71	$63,806	342.2	$22.71
			"	MCV	81	6.862	23.36	$78,974	411.7	$23.36
			"	HCV-I	30	6.862	32.86	$41,147	411.7	$32.86
			"	HCV-II	30	6.862	42.36	$53,044	411.7	$42.36
Northbound	Total	Days	365	Car	2487	5.957	17.45	$1,572,713	357.4	$17.45
			"	LCV	81	5.957	22.71	$66,651	357.4	$22.71
			"	MCV	81	8.489	23.36	$97,697	509.3	$23.36
			"	HCV-I	30	8.489	32.86	$50,902	509.3	$32.86
			"	HCV-II	30	8.489	42.36	$65,620	509.3	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$3,385,403**		
		($1505562 + $63806 + $78974) + ($1572713 + $66651 + $97697) =								
Annual Cost	=	(HCV-II, HCV-II)						**$210,713**		
		($41147 + $53044) + ($50902 + $65620) =								
REALIGNMENT OPTIONS				AADT =	5464	(Yr 2)				
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2487	3.963	17.45	$1,046,138	237.8	$17.45
			"	LCV	81	3.963	22.71	$44,335	237.8	$22.71
			"	MCV	81	4.544	23.36	$52,295	272.6	$23.36
			"	HCV-I	30	4.544	32.86	$27,247	272.6	$32.86
			"	HCV-II	30	4.544	42.36	$35,125	272.6	$42.36
Northbound	Total	Days	365	Car	2487	3.963	17.45	$1,046,138	237.8	$17.45
			"	LCV	81	3.963	22.71	$44,335	237.8	$22.71
			"	MCV	81	5.410	23.36	$62,256	324.6	$23.36
			"	HCV-I	30	5.410	32.86	$32,437	324.6	$32.86
			"	HCV-II	30	5.410	42.36	$41,815	324.6	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$2,295,499**		
		($1046138 + $44335 + $52295) + ($1046138 + $44335 + $62256) =								
Annual Cost	=	(HCV-II, HCV-II)						**$136,624**		
		($27247 + $35125) + ($32437 + $41815) =								

COST-BENEFIT ANALYSIS OF THE OPTIONS:

Pre-Construction Economics

1. Project Options	Do Minimum	Option A				Do Minimum	Option A	0	0	0 0
COSTS:							Net Costs of the Project Options ($)			
2. Capital Costs		$12,360,548				Nil	$12,360,548			
3. Maintenance Costs		$293,793				$1,118,410	($824,617)			
4. Total Costs (2) + (3)							$11,535,931			
BENEFITS:							Net Benefits of the Project Options ($)			
5. Travel Time Costs	$55,281,108	$43,694,201					$11,586,907			
6. Vehicle Operating Costs	$49,933,890	$44,319,947					$5,613,943			
7. Accident Costs	36,426,359	$17,227,128					$19,199,231			
8. Passing Lane Benefits		$1,578,949					$1,578,949			
9. Carbon Dioxide	$2,166,161	$2,028,513					$137,648			
10. Tangible Benefits (5) to (9)							$38,116,678			
11. Tangible B/C Ratio (10) / (4)							See Sheet 2	#VALUE!	#VALUE!	#VALUE!
12. Ranking B/C Ratio										
13. Intangible Benefits {(12) - (11)} * (4)										

COST-BENEFIT ANALYSIS OF THE OPTIONS:

Pre-Construction Economics

1. Project Options	Do Minimum	Option A				Do Minimum	Option A	0	0	0 0
COSTS:							Net Costs of the Project Options ($)			
14. Capital Costs						Nil				
15. Maintenance Costs										
16. Total Costs (4)							$11,535,931			
BENEFITS:							Net Benefits of the Project Options ($)			
17. Tangible Benefits (10)							$38,116,678			
18. Accident Disruption		$1,908,359					$1,908,359			
19. Acc Save - Passing Lane		$387,530					$387,530			
20.										
21.										
22. Tangible Benefits (17) to (21)							$40,412,567			
23. Tangible B/C Ratio (22) / (16)							3.5	#VALUE!	#VALUE!	#VALUE!

DISCOUNTING **WORKSHEET A1.2**

1 Option : Do Minimum 2 Base Date: 1/07/01 3 Time Zero : 1/07/02

4	TYPE OF COST OR BENEFIT			Travel Time Costs				
5	YEAR OF ESTIMATE			1994				
			Light Vehicles	HCV	HCV			
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount				968,539			
(b)	Start Time, s				5.00%			
(c)	End Time, e				48426.95			
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
				HCV	HCV			
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)		3,044,238	808,314	871,685		470,000	
(b)	Arithmetic Growth Rate		3.6%	10.0%	5.6%		3.6%	
(c)	Start Time, s		0	0	2		0	
(d)	End Time, e		25	2	25		25	
(e)	USPWF for s years		0.0000	0.0000	1.8209		0.0000	
(f)	USPWF for e years		9.5237	1.8209	9.5237		9.5237	
(g)	AGPWF for s years		0.0000	0.0000	1.7631		0.0000	
(h)	AGPWF for e years		75.7137	1.7631	75.7137		75.7137	
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	37,290,015	1,614,403	10,295,570		5,757,207	
9	TOTAL PV TIME ZERO				49,199,989			
10	UPDATE FACTOR for Year of Estimate				1.12			
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)			55,281,108			

4	TYPE OF COST OR BENEFIT		Vehicle Operating Costs					
5	YEAR OF ESTIMATE		1994					
			Light Vehicles		HCV		HCV	
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount							
(b)	Start Time, s						503,711	511,741
(c)	End Time, e						5.00%	5.00%
(d)	USPWF for s years						25186	25587
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
8	ARITHMETIC GROWTH:		(Southbound)	(Northbound)	(Southbound)	(Northbound)	(Southbound)	(Northbound)
(a)	Initial Amount (Time Zero)		1,479,725	1,577,329	420,391	427,091	453,340	460,567
(b)	Arithmetic Growth Rate		3.6%	3.6%	10.0%	10.0%	5.6%	5.6%
(c)	Start Time, s		0	0	0	0	2	2
(d)	End Time, e		25	25	2	2	25	25
(e)	USPWF for s years		0.0000	0.0000	0.0000	0.0000	1.8209	1.8209
(f)	USPWF for e years		9.5237	9.5237	1.8209	1.8209	9.5237	9.5237
(g)	AGPWF for s years		0.0000	0.0000	0.0000	0.0000	1.7631	1.7631
(h)	AGPWF for e years		75.7137	75.7137	1.7631	1.7631	75.7137	75.7137
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	18,125,708	19,321,296	839,625	853,007	5,354,448	5,439,807
9	TOTAL PV TIME ZERO							49,933,890
10	UPDATE FACTOR for Year of Estimate	2001						1.00
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)						49,933,890

DISCOUNTING **WORKSHEET A1.2**

1 Option : Do Minimum 2 Base Date: 1/07/01 3 Time Zero : 1/07/02

4	TYPE OF COST OR BENEFIT	Carbon Dioxide Emission Costs					
5	YEAR OF ESTIMATE	1994					
		Light Vehicles		HCV		HCV	
6	SINGLE PAYMENT:						
(a)	Amount						
(b)	Time, n						
(c)	SPPWF for Time n						
(d)	PV Time Zero (a) x (c)						
6	SINGLE PAYMENT:						
(a)	Amount						
(b)	Time, n						
(c)	SPPWF for Time n						
(d)	PV Time Zero (a) x (c)						
6	SINGLE PAYMENT:						
(a)	Amount						
(b)	Time, n						
(c)	SPPWF for Time n						
(d)	PV Time Zero (a) x (c)						
7	UNIFORM SERIES:						
(a)	Annual Amount					21,861	21,837
(b)	Start Time, s					5.0%	5.0%
(c)	End Time, e					1093.05	1091.85
(d)	USPWF for s years						
(e)	USPWF for e years						
(f)	PV Time Zero (a) x {(e) - (d)}						
8	ARITHMETIC GROWTH:	(Southbound)	(Northbound)	(Southbound)	(Northbound)	(Southbound)	(Northbound)
(a)	Initial Amount (Time Zero)	64,629	68,342	18,245	18,225	19,675	19,653
(b)	Arithmetic Growth Rate	3.6%	3.6%	10.0%	10.0%	5.6%	5.6%
(c)	Start Time, s	0	0	0	0	2	2
(d)	End Time, e	25	25	2	2	25	25
(e)	USPWF for s years	0.0000	0.0000	0.0000	0.0000	1.8209	1.8209
(f)	USPWF for e years	9.5237	9.5237	1.8209	1.8209	9.5237	9.5237
(g)	AGPWF for s years	0.0000	0.0000	0.0000	0.0000	1.7631	1.7631
(h)	AGPWF for e years	75.7137	75.7137	1.7631	1.7631	75.7137	75.7137
(i)	PV Time Zero (a) x [(f) - (e) + (b) x {(h) - (g)}]	791,665	837,147	36,440	36,400	232,382	232,127
9	TOTAL PV TIME ZERO						2,166,161
10	UPDATE FACTOR for Year of Estimate						1.00
11	TOTAL PV TIME ZERO Adjusted to Base Date (9) x (10)						2,166,161

4	TYPE OF COST OR BENEFIT		Road Maintenance Costs					
			9.750-10.075	10.075-10.800-10.990		10.990-11.660-13.750		
5	YEAR OF ESTIMATE		1996	1996		1996	1996	1996
6	SINGLE PAYMENT:		(Reseal)	(Maint. SCT)	(Reseal)	(Reseal)	(Shape Correction)	(Reseal)
(a)	Amount		7,800	90,000	7,752	27,336	459,800	27,336
(b)	Time, n		7	0	11	2	6	26
(c)	SPPWF for Time n		0.5132	1.0000	0.3505	0.8264	0.5645	0.0839
(d)	PV Time Zero	(a) x (c)	4,003	90,000	2,717	22,592	259,545	2,294
6	SINGLE PAYMENT:		(Shape Correction)	(2nd Coat Seal)	(Shape Correction)	(Reseal)	(Reseal)	(Reseal)
(a)	Amount		71,500	16,000	159,500	55,176	27,336	55,176
(b)	Time, n		17	1	21	2	16	26
(c)	SPPWF for Time n		0.1978	0.9091	0.1351	0.8264	0.2176	0.0839
(d)	PV Time Zero	(a) x (c)	14,146	14,545	21,553	45,600	5,949	4,630
6	SINGLE PAYMENT:			(Reseal)	(Shape Correction)	(Shape Correction)	(Reseal)	
(a)	Amount			17,400	41,800	147,400	55,176	
(b)	Time, n			11	21	6	16	
(c)	SPPWF for Time n			0.3505	0.1351	0.5645	0.2176	
(d)	PV Time Zero	(a) x (c)		6,099	5,648	83,203	12,008	
7	UNIFORM SERIES:		(General Maint)	(General Maint)	(General Maint)	(General Maint)	(General Maint)	
(a)	Annual Amount		3,250	7,250	1,900	6,700	20,900	
(b)	Start Time, s		0	0	0	0	0	
(c)	End Time, e		26	26	26	26	26	
(d)	USPWF for s years		0.0000	0.0000	0.0000	0.0000	0.0000	
(e)	USPWF for e years		9.6117	9.6117	9.6117	9.6117	9.6117	
(f)	PV Time Zero	(a) x {(e) - (d)}	31,238	69,685	18,262	64,399	200,885	
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)							
(b)	Arithmetic Growth Rate							
(c)	Start Time, s							
(d)	End Time, e							
(e)	USPWF for s years							
(f)	USPWF for e years							
(g)	AGPWF for s years							
(h)	AGPWF for e years							
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]						
9	TOTAL PV TIME ZERO		49,387		228,510			701,104
10	UPDATE FACTOR for Year of Estimate							1.14
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)						1,118,410

DISCOUNTING **WORKSHEET A1.2**

1 Option : Do Minimum   2 Base Date: 1/07/01   3 Time Zero : 1/07/02

4	TYPE OF COST OR BENEFIT		Accident (1996 - 2000) Costs					
5	YEAR OF ESTIMATE		1998					
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount							
(b)	Start Time, s							
(c)	End Time, e							
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
8	ARITHMETIC GROWTH:		(Mid-Block)	(Intersections)				
(a)	Initial Amount (Time Zero)		2,967,363	22,871				
(b)	Arithmetic Growth Rate		2.6%	2.6%				
(c)	Start Time, s		0	0				
(d)	End Time, e		25	25				
(e)	USPWF for s years		0.0000	0.0000				
(f)	USPWF for e years		9.5237	9.5237				
(g)	AGPWF for s years		0.0000	0.0000				
(h)	AGPWF for e years		75.7137	75.7137				
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	34,101,649	262,841				
9	TOTAL PV TIME ZERO			34,364,490				
10	UPDATE FACTOR for Year of Estimate			1.06				
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)		36,426,359				

4	TYPE OF COST OR BENEFIT							
5	YEAR OF ESTIMATE							
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
(d)	PV Time Zero	(a) x (c)	0	0	0	0	0	0
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
(d)	PV Time Zero	(a) x (c)	0	0	0	0	0	0
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n			1.0000	1.0000	1.0000	1.0000	
(d)	PV Time Zero	(a) x (c)		0	0	0	0	
7	UNIFORM SERIES:							
(a)	Annual Amount							
(b)	Start Time, s							
(c)	End Time, e							
(d)	USPWF for s years		0.0000	0.0000	0.0000	0.0000	0.0000	
(e)	USPWF for e years		0.0000	0.0000	0.0000	0.0000	0.0000	
(f)	PV Time Zero	(a) x {(e) - (d)}	0	0	0	0	0	
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)							
(b)	Arithmetic Growth Rate							
(c)	Start Time, s							
(d)	End Time, e							
(e)	USPWF for s years							
(f)	USPWF for e years							
(g)	AGPWF for s years							
(h)	AGPWF for e years							
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]						
9	TOTAL PV TIME ZERO		0		0			0
10	UPDATE FACTOR for Year of Estimate							
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)	0		0			0

DISCOUNTING

WORKSHEET A1.2

1 Option : A 2 Base Date: 1/07/01 3 Time Zero : 1/07/02

4	TYPE OF COST OR BENEFIT			Travel Time				
				Costs				
5	YEAR OF ESTIMATE			1994				
			Light Vehicles	HCV	Light Vehicles	HCV		
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount					817,925		
(b)	Start Time, s					5.0%		
(c)	End Time, e					40896.25		
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
8	ARITHMETIC GROWTH:		(Do Minimum)	(Do Minimum)	(Option)	(Option)		
(a)	Initial Amount (Time Zero)		3,044,238	808,314	2,203,784	736,133		
(b)	Arithmetic Growth Rate		3.6%	10.0%	3.6%	5.6%		
(c)	Start Time, s		0	0	2	2		
(d)	End Time, e		2	2	25	25		
(e)	USPWF for s years		0.0000	0.0000	1.8209	1.8209		
(f)	USPWF for e years		1.8209	1.8209	9.5237	9.5237		
(g)	AGPWF for s years		0.0000	0.0000	1.7631	1.7631		
(h)	AGPWF for e years		1.7631	1.7631	75.7137	75.7137		
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	5,736,587	1,614,403	22,842,150	8,694,543		
9	TOTAL PV TIME ZERO					38,887,683		
10	UPDATE FACTOR for Year of Estimate					1.12		
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)				43,694,201		

4	TYPE OF COST OR BENEFIT	Vehicle Operating Costs					
5	YEAR OF ESTIMATE	1994					
		Light Vehicles		HCV		Light Vehicles	
6	SINGLE PAYMENT:						
(a)	Amount						
(b)	Time, n						
(c)	SPPWF for Time n						
(d)	PV Time Zero (a) x (c)						
6	SINGLE PAYMENT:						
(a)	Amount						
(b)	Time, n						
(c)	SPPWF for Time n						
(d)	PV Time Zero (a) x (c)						
6	SINGLE PAYMENT:						
(a)	Amount						
(b)	Time, n						
(c)	SPPWF for Time n						
(d)	PV Time Zero (a) x (c)						
				option scenario			
7	UNIFORM SERIES:						
(a)	Annual Amount						
(b)	Start Time, s						
(c)	End Time, e						
(d)	USPWF for s years						
(e)	USPWF for e years						
(f)	PV Time Zero (a) x {(e) - (d)}	LIGHTS		HCV		LIGHTS	
		(Southbound)	(Northbound)	(Southbound)	(Northbound)	(Southbound)	(Northbound)
8	ARITHMETIC GROWTH:	(Do Minimum)	(Do Minimum)	(Do Minimum)	(Do Minimum)	(Option)	(Option)
(a)	Initial Amount (Time Zero)	1,324,572	1,422,655	354,855	369,189	1,324,572	1,422,655
(b)	Arithmetic Growth Rate	3.6%	3.6%	10.0%	10.0%	3.6%	3.6%
(c)	Start Time, s	0	0	0	0	2	2
(d)	End Time, e	2	2	2	2	25	25
(e)	USPWF for s years	0.0000	0.0000	0.0000	0.0000	1.8209	1.8209
(f)	USPWF for e years	1.8209	1.8209	1.8209	1.8209	9.5237	9.5237
(g)	AGPWF for s years	0.0000	0.0000	0.0000	0.0000	1.7631	1.7631
(h)	AGPWF for e years	1.7631	1.7631	1.7631	1.7631	75.7137	75.7137
(i)	PV Time Zero (a) x [(f) - (e) + (b) x {(h) - (g)}]	2,496,034	2,680,863	708,733	737,362	13,729,146	14,745,773
9	TOTAL PV TIME ZERO						
10	UPDATE FACTOR for Year of Estimate						
11	TOTAL PV TIME ZERO Adjusted to Base Date (9) x (10)						

DISCOUNTING

WORKSHEET A1.2

1 Option : A | 2 Base Date: 1/07/01 | 3 Time Zero : 1/07/02

4	TYPE OF COST OR BENEFIT		Carbon Dioxide Emission Costs					
5	YEAR OF ESTIMATE		1994					
			Light Vehicles		Light Vehicles		HCV	
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount				63,479	68,228		
(b)	Start Time, s				3.6%	3.6%		
(c)	End Time, e				2285.244	2456.208		
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
			(Southbound) (Do Minimum)	(Northbound) (Do Minimum)	(Southbound) (Option)	(Northbound) (Option)	(Southbound) (Do Minimum)	(Northbound) (Do Minimum)
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)		64,629	68,342	58,909	63,316	18,245	18,225
(b)	Arithmetic Growth Rate		3.6%	3.6%	3.9%	3.9%	10.0%	10.0%
(c)	Start Time, s		0	0	2	2	0	0
(d)	End Time, e		2	2	25	25	2	2
(e)	USPWF for s years		0.0000	0.0000	1.8209	1.8209	0.0000	0.0000
(f)	USPWF for e years		1.8209	1.8209	9.5237	9.5237	1.8209	1.8209
(g)	AGPWF for s years		0.0000	0.0000	1.7631	1.7631	0.0000	0.0000
(h)	AGPWF for e years		1.7631	1.7631	75.7137	75.7137	1.7631	1.7631
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	121,787	128,784	622,752	669,342	36,440	36,400
9	TOTAL PV TIME ZERO							
10	UPDATE FACTOR for Year of Estimate							
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)						

4	TYPE OF COST OR BENEFIT		Vehicle Operating Costs					
5	YEAR OF ESTIMATE		1994					
			HCV					
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount		425,186	442,362				
(b)	Start Time, s		5.0%	5.0%				
(c)	End Time, e		21259.3	22118.1				
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}	HCV					
			(Southbound) (Option)	(Northbound) (Option)				
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)		382,667	398,126				
(b)	Arithmetic Growth Rate		5.6%	5.6%				
(c)	Start Time, s		2	2				
(d)	End Time, e		25	25				
(e)	USPWF for s years		1.8209	1.8209				
(f)	USPWF for e years		9.5237	9.5237				
(g)	AGPWF for s years		1.7631	1.7631				
(h)	AGPWF for e years		75.7137	75.7137				
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	4,519,727	4,702,308				
9	TOTAL PV TIME ZERO		44,319,947					
10	UPDATE FACTOR for Year of Estimate		1.00					
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)	44,319,947					

DISCOUNTING

WORKSHEET A1.2

1 Option : A 2 Base Date: 1/07/01 3 Time Zero : 1/07/02

No.	Item	Formula						
4	TYPE OF COST OR BENEFIT		Carbon Dioxide Emission Costs					
5	YEAR OF ESTIMATE		1994					
			HCV					
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount		19,040	19,813				
(b)	Start Time, s		5.0%	5.0%				
(c)	End Time, e		952	990.65				
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
			(Southbound)	(Northbound)				
8	ARITHMETIC GROWTH:		(Option)	(Option)				
(a)	Initial Amount (Time Zero)		17,136	17,832				
(b)	Arithmetic Growth Rate		5.6%	5.6%				
(c)	Start Time, s		2	2				
(d)	End Time, e		25	25				
(e)	USPWF for s years		1.8209	1.8209				
(f)	USPWF for e years		9.5237	9.5237				
(g)	AGPWF for s years		1.7631	1.7631				
(h)	AGPWF for e years		75.7137	75.7137				
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	202,395	210,612				
9	TOTAL PV TIME ZERO			2,028,513				
10	UPDATE FACTOR for Year of Estimate			1.00				
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)		2,028,513				

4	TYPE OF COST OR BENEFIT		Maintenance Costs					
5	YEAR OF ESTIMATE		1994					
6	SINGLE PAYMENT:			Reseals Option				
(a)	Amount			181,620				
(b)	Time, n			13				
(c)	SPPWF for Time n			0.2897				
(d)	PV Time Zero	(a) x (c)		52,609				
6	SINGLE PAYMENT:			Option				
(a)	Amount			181,620				
(b)	Time, n			23				
(c)	SPPWF for Time n			0.1117				
(d)	PV Time Zero	(a) x (c)		20,283				
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount		27,600	27,200	6,450	6,900		
(b)	Start Time, s		0	0	1	2		
(c)	End Time, e		1	2	25	25		
(d)	USPWF for s years		0.0000	0.0000	0.9538	1.8209		
(e)	USPWF for e years		0.9538	1.8209	9.5237	9.5237		
(f)	PV Time Zero	(a) x {(e) - (d)}	26,326	49,529	55,276	53,149		
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)							
(b)	Arithmetic Growth Rate							
(c)	Start Time, s							
(d)	End Time, e							
(e)	USPWF for s years							
(f)	USPWF for e years							
(g)	AGPWF for s years							
(h)	AGPWF for e years							
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]						
9	TOTAL PV TIME ZERO		257,171					
10	UPDATE FACTOR for Year of Estimate		1.14					
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)	293,793					

DISCOUNTING

WORKSHEET A1.2

1 Option : A   2 Base Date: 1/07/01   3 Time Zero : 1/07/02

4	TYPE OF COST OR BENEFIT		Accidents (1996 - 2000)					
			Costs					
5	YEAR OF ESTIMATE		1998					
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount							
(b)	Start Time, s							
(c)	End Time, e							
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
			(Do Minimum)	(Do Minimum)	(Option Mid Bl.)	(Option Mid Bl.)	(Option)	Service Rd
8	ARITHMETIC GROWTH:		(Mid Block)	(Intersections)	(North of Summit)	(South of Summit)	(Intersections)	Saving
(a)	Initial Amount (Time Zero)		2,967,363	22,871	556,600	624,437	38,242	-110770
(b)	Arithmetic Growth Rate		2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
(c)	Start Time, s		0	0	2	2	2	2
(d)	End Time, e		2	2	25	25	25	25
(e)	USPWF for s years		0.0000	0.0000	1.8209	1.8209	1.8209	1.8209
(f)	USPWF for e years		1.8209	1.8209	9.5237	9.5237	9.5237	9.5237
(g)	AGPWF for s years		0.0000	0.0000	1.7631	1.7631	1.7631	1.7631
(h)	AGPWF for e years		1.7631	1.7631	75.7137	75.7137	75.7137	75.7137
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]	5,539,405	42,695	5,357,532	6,010,495	368,092	(1,066,212)
9	TOTAL PV TIME ZERO							16,252,007
10	UPDATE FACTOR for Year of Estimate							1.06
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)						17,227,128

4	TYPE OF COST OR BENEFIT		Property Costs		Construction Costs			
5	YEAR OF ESTIMATE				2001			
6	SINGLE PAYMENT:		(Credit to Do Min - Resale Value)					
(a)	Amount		100,000					
(b)	Time, n		1					
(c)	SPPWF for Time n		0.9091					
(d)	PV Time Zero	(a) x (c)	90,909					
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount				5,000,000	8,650,000		
(b)	Start Time, s				0	1		
(c)	End Time, e				1	2		
(d)	USPWF for s years				0.0000	0.9538		
(e)	USPWF for e years				0.9538	1.8209		
(f)	PV Time Zero	(a) x {(e) - (d)}			4,769,118	7,500,521		
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)							
(b)	Arithmetic Growth Rate							
(c)	Start Time, s							
(d)	End Time, e							
(e)	USPWF for s years							
(f)	USPWF for e years							
(g)	AGPWF for s years							
(h)	AGPWF for e years							
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]						
9	TOTAL PV TIME ZERO					12,360,548		
10	UPDATE FACTOR for Year of Estimate					1.00		
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)				12,360,548		

DISCOUNTING

WORKSHEET A1.2

1 Option : A 2 Base Date: 1/07/01 3 Time Zero : 1/07/02

4	TYPE OF COST OR BENEFIT							
5	YEAR OF ESTIMATE							
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount							
(b)	Start Time, s							
(c)	End Time, e							
(d)	USPWF for s years		0.0000	0.0000	0.0000	0.0000		
(e)	USPWF for e years		0.0000	0.0000	0.0000	0.0000		
(f)	PV Time Zero	(a) x {(e) - (d)}	0	0	0	0		
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)							
(b)	Arithmetic Growth Rate							
(c)	Start Time, s							
(d)	End Time, e							
(e)	USPWF for s years							
(f)	USPWF for e years							
(g)	AGPWF for s years							
(h)	AGPWF for e years							
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]						
9	TOTAL PV TIME ZERO					0		
10	UPDATE FACTOR for Year of Estimate					1.02		
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)				0		

4	TYPE OF COST OR BENEFIT							
5	YEAR OF ESTIMATE							
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
6	SINGLE PAYMENT:							
(a)	Amount							
(b)	Time, n							
(c)	SPPWF for Time n							
(d)	PV Time Zero	(a) x (c)						
7	UNIFORM SERIES:							
(a)	Annual Amount							
(b)	Start Time, s							
(c)	End Time, e							
(d)	USPWF for s years							
(e)	USPWF for e years							
(f)	PV Time Zero	(a) x {(e) - (d)}						
8	ARITHMETIC GROWTH:							
(a)	Initial Amount (Time Zero)							
(b)	Arithmetic Growth Rate							
(c)	Start Time, s							
(d)	End Time, e							
(e)	USPWF for s years							
(f)	USPWF for e years							
(g)	AGPWF for s years							
(h)	AGPWF for e years							
(i)	PV Time Zero	(a) x [(f) - (e) + (b) x {(h) - (g)}]						
9	TOTAL PV TIME ZERO							
10	UPDATE FACTOR for Year of Estimate							
11	TOTAL PV TIME ZERO Adjusted to Base Date	(9) x (10)						

TRAVEL TIME COSTS

WORKSHEET A4.1

Option	Road Section / Movement	Time Period	Time Periods per Year	Vehicle Category	Vehicles per Time Period	Total Travel Time (min)	Travel Time Cost ($/hour)	Total Cost per Year ($)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		
DO MINIMUM				AADT =	5044					
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	1942	5.703	17.45	$1,175,597	342.2	$17.45
			"	LCV	227	5.703	22.71	$178,797	342.2	$22.71
			"	MCV	126	6.862	23.36	$122,946	411.7	$23.36
			"	HCV-I	101	6.862	32.86	$138,364	411.7	$32.86
			"	HCV-II	126	6.862	42.36	$222,963	411.7	$42.36
Northbound	Total	Days	365	Car	1942	5.957	17.45	$1,228,031	357.4	$17.45
			"	LCV	227	5.957	22.71	$186,772	357.4	$22.71
			"	MCV	126	8.489	23.36	$152,094	509.3	$23.36
			"	HCV-I	101	8.489	32.86	$171,166	509.3	$32.86
			"	HCV-II	126	8.489	42.36	$275,821	509.3	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$3,044,238**		
		($1175597 + $178797 + $122946) + ($1228031 + $186772 + $152094) =								
Annual Cost	=	(HCV-II, HCV-II)						**$808,314**		
		($138364 + $222963) + ($171166 + $275821) =								
REALIGNMENT OPTIONS				AADT =	5044					
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	1942	4.151	17.45	$855,625	249.1	$17.45
			"	LCV	227	4.151	22.71	$130,133	249.1	$22.71
			"	MCV	126	5.075	23.36	$90,923	304.5	$23.36
			"	HCV-I	101	5.075	32.86	$102,324	304.5	$32.86
			"	HCV-II	126	5.075	42.36	$164,888	304.5	$42.36
Northbound	Total	Days	365	Car	1942	4.151	17.45	$855,625	249.1	$17.45
			"	LCV	227	4.151	22.71	$130,133	249.1	$22.71
			"	MCV	126	7.889	23.36	$141,347	473.4	$23.36
			"	HCV-I	101	7.889	32.86	$159,072	473.4	$32.86
			"	HCV-II	126	7.889	42.36	$256,332	473.4	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$2,203,784**		
		($855625 + $130133 + $90923) + ($855625 + $130133 + $141347) =								
Annual Cost	=	(HCV-II, HCV-II)						**$682,616**		
		($102324 + $164888) + ($159072 + $256332) =								

DO MINIMUM				AADT =	5464	(Yr 2)				
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2082	5.703	17.45	$1,260,386	342.2	$17.45
			"	LCV	243	5.703	22.71	$191,417	342.2	$22.71
			"	MCV	135	6.862	23.36	$131,624	411.7	$23.36
			"	HCV-I	121	6.862	32.86	$165,960	411.7	$32.86
			"	HCV-II	151	6.862	42.36	$266,990	411.7	$42.36
Northbound	Total	Days	365	Car	2082	5.957	17.45	$1,316,601	357.4	$17.45
			"	LCV	243	5.957	22.71	$199,954	357.4	$22.71
			"	MCV	135	8.489	23.36	$162,828	509.3	$23.36
			"	HCV-I	121	8.489	32.86	$205,304	509.3	$32.86
			"	HCV-II	151	8.489	42.36	$330,285	509.3	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$3,262,810**		
		($1260386 + $191417 + $131624) + ($1316601 + $199954 + $162828) =								
Annual Cost	=	(HCV-II, HCV-II)						**$968,539**		
		($165960 + $266990) + ($205304 + $330285) =								
REALIGNMENT OPTIONS				AADT =	5464	(Yr 2)				
									TT (sec)	TT ($/hr)
Southbound	Total	Days	365	Car	2082	4.151	17.45	$917,335	249.1	$17.45
			"	LCV	243	4.151	22.71	$139,317	249.1	$22.71
			"	MCV	135	5.075	23.36	$97,340	304.5	$23.36
			"	HCV-I	121	5.075	32.86	$122,732	304.5	$32.86
			"	HCV-II	151	5.075	42.36	$197,447	304.5	$42.36
Northbound	Total	Days	365	Car	2082	4.151	17.45	$917,335	249.1	$17.45
			"	LCV	243	4.151	22.71	$139,317	249.1	$22.71
			"	MCV	135	7.889	23.36	$151,323	473.4	$23.36
			"	HCV-I	121	7.889	32.86	$190,798	473.4	$32.86
			"	HCV-II	151	7.889	42.36	$306,948	473.4	$42.36
Annual Cost	=	(Car, LVC, MCV)						**$2,361,968**		
		($917335 + $139317 + $97340) + ($917335 + $139317 + $151323) =								
Annual Cost	=	(HCV-II, HCV-II)						**$817,925**		
		($122732 + $197447) + ($190798 + $306948) =								

VEHICLE OPERATING COSTS A: WORKSHEET A5.1

Option	Section/ Movement	Section Length (m)	Average Gradient (%)	Surface Roughness counts/km	Period		Vehicle Type	Section Speed (km/h)	Base Cost (cents/km)	Roughness Cost (cents/km)	Speed Changes & Stops		Queuing Delay		Section Cost (cents)
					From	To					Min Speed (km/h)	Add. Cost (cents)	Time (mins)	Fuel (cents)	
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
DO MINIMUM - Southbound							AADT =	5044							
	1	620	1.13%	70	All	All	Car	78	28.12	0.17	80-60-80	0.5	-	-	18.04
	"	"	"	"	"	"	LCV	78	23.84	0.18	80-60-80	0.4	-	-	15.29
	"	"	"	"	"	"	MCV	78	44.02	0.17	80-55-80	2.0	-	-	29.40
	"	"	"	"	"	"	HCV-I	78	57.54	0.33	80-55-80	4.5	-	-	40.38
	"	"	"	"	"	"	HCV-II	78	69.76	0.40	80-55-80	10.3	-	-	53.80
	2	1410	2.31%	70	All	All	Car	63	28.87	0.17	65-50-65	0.3	-	-	41.24
	"	"	"	"	"	"	LCV	63	24.06	0.18	65-50-65	0.2	-	-	34.38
	"	"	"	"	"	"	MCV	63	45.50	0.17	65-45-65	1.5	-	-	65.89
	"	"	"	"	"	"	HCV-I	63	61.18	0.33	65-45-65	3.1	-	-	89.82
	"	"	"	"	"	"	HCV-II	63	78.87	0.40	65-45-65	7.0	-	-	118.77
	3	500	-3.09%	90	All	All	Car	62	25.71	1.38	65-50-65	0.3	-	-	13.84
	"	"	"	"	"	"	LCV	62	20.03	1.47	65-50-65	0.2	-	-	10.95
	"	"	"	"	"	"	MCV	50	38.35	2.74	-	-	-	-	20.55
	"	"	"	"	. "	"	HCV-I	50	47.57	5.66	-	-	-	-	26.62
	"	"	"	"	"	"	HCV-II	50	54.39	5.65	-	-	-	-	30.02
DO MINIMUM - Southbound (Continued)							AADT =	5044							
	4	680	5.24%	87	All	All	Car	62	30.83	1.16	-	-	-	-	21.75
	"	"	"	"	"	"	LCV	62	26.16	1.23	-	-	-	-	18.62
	"	"	"	"	"	"	MCV	45	50.91	2.15	-	-	-	-	36.08
	"	"	"	"	"	"	HCV-I	45	73.25	4.35	-	-	-	-	52.77
	"	"	"	"	"	"	HCV-II	45	104.63	4.43	-	-	-	-	74.16
	5	400	-4.43%	86	All	All	Car	58	25.68	1.08	60-40-60	0.4	-	-	11.11
	"	"	"	"	"	"	LCV	58	19.95	1.15	60-40-60	0.4	-	-	8.84
	"	"	"	"	"	"	MCV	35	41.21	1.95	-	-	-	-	17.26
	"	"	"	"	"	"	HCV-I	35	53.88	3.92	-	-	-	-	23.12
	"	"	"	"	"	"	HCV-II	35	65.77	4.02	-	-	-	-	27.92
	6	980	-10.00%	86	All	All	Car	58	25.68	1.08	60-50-60	0.2	-	-	26.43
	"	"	"	"	"	"	LCV	58	19.95	1.15	60-50-60	0.1	-	-	20.78
	"	"	"	"	"	"	MCV	40	58.69	1.95	-	-	-	-	59.43
	"	"	"	"	"	"	HCV-I	40	97.06	3.92	-	-	-	-	98.96
	"	"	"	"	"	"	HCV-II	40	152.21	4.02	-	-	-	-	153.10
DO MINIMUM - Southbound (Continued)							AADT =	5044							
	7	400	-8.34%	86	All	All	Car	58	25.68	1.08	60-40-60	0.4	-	-	11.10
	"	"	"	"	"	"	LCV	58	19.95	1.15	60-40-60	0.4	-	-	8.84
	"	"	"	"	"	"	MCV	50	49.81	1.95	50-35-50	0.9	-	-	21.60
	"	"	"	"	"	"	HCV-I	50	76.46	3.92	50-35-50	2.0	-	-	34.15
	"	"	"	"	"	"	HCV-II	50	113.89	4.02	50-35-50	4.0	-	-	51.16
	8	1110	-3.18%	86	All	All	Car	74	25.57	1.08	-	-	-	-	29.58
	"	"	"	"	"	"	LCV	74	20.14	1.15	-	-	-	-	23.64
	"	"	"	"	"	"	MCV	74	37.61	1.95	75-65-75	0.7	-	-	44.61
	"	"	"	"	"	"	HCV-I	74	45.93	3.92	75-65-75	1.7	-	-	57.03
	"	"	"	"	"	"	HCV-II	74	51.98	4.02	75-65-75	4.0	-	-	66.16

VEHICLE OPERATING COSTS A: WORKSHEET A5.1

Option	Section/ Movement	Section Length (m)	Average Gradient (%)	Surface Roughness counts/km	Period From	Period To	Vehicle Type	Section Speed (km/h)	Base Cost (cents/km)	Roughness Cost (cents/km)	Speed Changes & Stops Min Speed (km/h)	Speed Changes & Stops Add. Cost (cents)	Queuing Delay Time (mins)	Queuing Delay Fuel (cents)	Section Cost (cents)
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
DO MINIMUM - Northbound							AADT =	5044							
	1	620	-1.13%	72	All	All	Car	76	26.65	0.23	80-60-80	0.5	-	-	17.17
	"	"	"	"	"	"	LCV	76	21.57	0.25	80-60-80	0.4	-	-	13.93
	"	"	"	"	"	"	MCV	76	40.85	0.23	80-55-80	2.0	-	-	27.47
	"	"	"	"	"	"	HCV-I	76	50.07	0.46	80-55-80	4.5	-	-	35.83
	"	"	"	"	"	"	HCV-II	76	52.59	0.56	80-55-80	10.3	-	-	43.25
	2	1410	-2.31%	72	All	All	Car	61	26.04	0.23	65-50-65	0.3	-	-	37.34
	"	"	"	"	"	"	LCV	61	20.50	0.25	65-50-65	0.2	-	-	29.45
	"	"	"	"	"	"	MCV	61	37.87	0.23	65-45-65	1.5	-	-	55.23
	"	"	"	"	"	"	HCV-I	61	46.18	0.46	65-45-65	3.1	-	-	68.86
	"	"	"	"	"	"	HCV-II	61	51.26	0.56	65-45-65	7.0	-	-	80.06
	3	500	3.09%	83	All	All	Car	65	29.35	0.87	65-50-65	0.3	-	-	15.41
	"	"	"	"	"	"	LCV	65	24.69	0.92	65-50-65	0.2	-	-	13.00
	"	"	"	"	"	"	MCV	65	47.24	1.35	65-45-65	1.5	-	-	25.80
	"	"	"	"	"	"	HCV-I	65	64.84	2.61	65-45-65	3.1	-	-	36.82
	"	"	"	"	"	"	HCV-II	65	86.19	2.80	65-45-65	7.0	-	-	51.49
DO MINIMUM - Northbound (Continued)							AADT =	5044							
	4	680	-5.24%	83	All	All	Car	65	25.47	0.87	-	-	-	-	17.91
	"	"	"	"	"	"	LCV	65	19.80	0.92	-	-	-	-	14.09
	"	"	"	"	"	"	MCV	56	40.46	1.35	-	-	-	-	28.44
	"	"	"	"	"	"	HCV-I	56	53.54	2.61	-	-	-	-	38.18
	"	"	"	"	"	"	HCV-II	56	68.19	2.80	-	-	-	-	48.27
	5	400	4.43%	95	All	All	Car	52	30.42	1.77	-	-	-	-	12.88
	"	"	"	"	"	"	LCV	52	25.28	1.88	-	-	-	-	10.87
	"	"	"	"	"	"	MCV	24	50.31	3.74	-	-	-	-	21.62
	"	"	"	"	"	"	HCV-I	24	71.38	7.85	-	-	-	-	31.69
	"	"	"	"	"	"	HCV-II	24	99.47	7.68	-	-	-	-	42.86
	6	980	10.00%	95	All	All	Car	52	33.91	1.77	55-40-55	0.3	-	-	35.26
	"	"	"	"	"	"	LCV	52	29.44	1.88	55-40-55	0.3	-	-	31.00
	"	"	"	"	"	"	MCV	23	61.86	3.74	-	-	-	-	64.29
	"	"	"	"	"	"	HCV-I	23	96.08	7.85	-	-	-	-	101.85
	"	"	"	"	"	"	HCV-II	23	150.56	7.68	-	-	-	-	155.07
DO MINIMUM - Northbound (Continued)							AADT =	5044							
	7	400	8.34%	95	All	All	Car	52	32.86	1.77	55-40-55	0.3	-	-	14.15
	"	"	"	"	"	"	LCV	52	28.17	1.88	55-40-55	0.3	-	-	12.32
	"	"	"	"	"	"	MCV	31	57.60	3.74	-	-	-	-	24.54
	"	"	"	"	"	"	HCV-I	31	87.44	7.85	-	-	-	-	38.12
	"	"	"	"	"	"	HCV-II	31	133.59	7.68	-	-	-	-	56.51
	8	1110	3.18%	95	All	All	Car	71	29.42	1.77	-	-	-	-	34.62
	"	"	"	"	"	"	LCV	71	25.00	1.88	-	-	-	-	29.84
	"	"	"	"	"	"	MCV	61	47.20	3.74	-	-	-	-	56.54
	"	"	"	"	"	"	HCV-I	61	64.92	7.85	-	-	-	-	80.77
	"	"	"	"	"	"	HCV-II	61	86.66	7.68	-	-	-	-	104.71

VEHICLE OPERATING COSTS A: WORKSHEET A5.1

Option	Section/ Movement	Section Length (m)	Average Gradient (%)	Surface Roughness counts/km	Period		Vehicle Type	Section Speed (km/h)	Base Cost (cents/km)	Roughness Cost (cents/km)	Speed Changes & Stops		Queuing Delay		Section Cost (cents)
					From	To					Min Speed (km/h)	Add. Cost (cents)	Time (mins)	Fuel (cents)	
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
REALIGNMENT OPTIONS - Southbound							AADT =	5044							
	1	410	1.13%	70	All	All	Car	90	28.40	0.17	-	-	-	-	11.71
	"	"	"	"	"	"	LCV	90	24.51	0.18	-	-	-	-	10.12
	"	"	"	"	"	"	MCV	78	44.02	0.17	-	-	-	-	18.12
	"	"	"	"	"	"	HCV-I	78	57.54	0.33	-	-	-	-	23.73
	"	"	"	"	"	"	HCV-II	78	69.76	0.40	-	-	-	-	28.77
	2	1410	2.31%	70	All	All	Car	80	28.93	0.17	-	-	-	-	41.04
	"	"	"	"	"	"	LCV	80	24.80	0.18	-	-	-	-	35.23
	"	"	"	"	"	"	MCV	63	45.50	0.17	-	-	-	-	64.39
	"	"	"	"	"	"	HCV-I	63	61.18	0.33	-	-	-	-	86.72
	"	"	"	"	"	"	HCV-II	63	78.87	0.40	-	-	-	-	111.77
	3	500	-3.09%	70	All	All	Car	80	25.65	0.17	-	-	-	-	12.91
	"	"	"	"	"	"	LCV	80	20.38	0.18	-	-	-	-	10.28
	"	"	"	"	"	"	MCV	65	37.70	0.17	-	-	-	-	18.94
	"	"	"	"	"	"	HCV-I	65	46.27	0.33	-	-	-	-	23.30
	"	"	"	"	"	"	HCV-II	65	52.51	0.40	-	-	-	-	26.45
REALIGNMENT OPTIONS - Southbound (Continued)							AADT =	5044							
	4	680	5.24%	70	All	All	Car	80	30.89	0.17	-	-	-	-	21.12
	"	"	"	"	"	"	LCV	80	27.05	0.18	-	-	-	-	18.52
	"	"	"	"	"	"	MCV	54	51.17	0.17	-	-	-	-	34.91
	"	"	"	"	"	"	HCV-I	54	73.64	0.33	-	-	-	-	50.30
	"	"	"	"	"	"	HCV-II	54	104.73	0.40	-	-	-	-	71.49
	5	400	-4.43%	70	All	All	Car	80	25.27	0.17	-	-	-	-	10.18
	"	"	"	"	"	"	LCV	80	19.83	0.18	-	-	-	-	8.00
	"	"	"	"	"	"	MCV	51	39.65	0.17	-	-	-	-	15.93
	"	"	"	"	"	"	HCV-I	51	51.08	0.33	-	-	-	-	20.56
	"	"	"	"	"	"	HCV-II	51	62.22	0.40	-	-	-	-	25.05
	6	980	-10.00%	70	All	All	Car	80	25.16	0.17	-	-	-	-	24.82
	"	"	"	"	"	"	LCV	80	19.55	0.18	-	-	-	-	19.34
	"	"	"	"	"	"	MCV	78	51.38	0.17	-	-	-	-	50.52
	"	"	"	"	"	"	HCV-I	78	83.69	0.33	-	-	-	-	82.34
	"	"	"	"	"	"	HCV-II	78	136.98	0.40	-	-	-	-	134.63
REALIGNMENT OPTIONS - Southbound (Continued)							AADT =	5044							
	7	400	-8.34%	70	All	All	Car	80	25.16	0.17	-	-	-	-	10.13
	"	"	"	"	"	"	LCV	80	19.55	0.18	-	-	-	-	7.89
	"	"	"	"	"	"	MCV	80	45.13	0.17	-	-	-	-	18.12
	"	"	"	"	"	"	HCV-I	80	67.74	0.33	-	-	-	-	27.23
	"	"	"	"	"	"	HCV-II	80	103.73	0.40	-	-	-	-	41.65
	8	900	-3.18%	70	All	All	Car	90	25.84	0.17	-	-	-	-	23.41
	"	"	"	"	"	"	LCV	90	20.79	0.18	-	-	-	-	18.87
	"	"	"	"	"	"	MCV	80	37.78	0.17	-	-	-	-	34.16
	"	"	"	"	"	"	HCV-I	80	45.75	0.33	-	-	-	-	41.47
	"	"	"	"	"	"	HCV-II	80	51.43	0.40	-	-	-	-	46.65

Option	Section/ Movement	Section Length (m)	Average Gradient (%)	Surface Roughness counts/km	Period		Vehicle Type	Section Speed (km/h)	Base Cost (cents/km)	Roughness Cost (cents/km)	Speed Changes & Stops		Queuing Delay		Section Cost (cents)
					From	To					Min Speed (km/h)	Add. Cost (cents)	Time (mins)	Fuel (cents)	
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
REALIGNMENT OPTIONS - Northbound							AADT =	5044							
	1	410	-1.13%	70	All	All	Car	90	26.91	0.17	-	-	-	-	11.10
	"	"	"	"	"	"	LCV	90	22.13	0.18	-	-	-	-	9.15
	"	"	"	"	"	"	MCV	80	41.51	0.17	-	-	-	-	17.09
	"	"	"	"	"	"	HCV-I	80	50.85	0.33	-	-	-	-	20.99
	"	"	"	"	"	"	HCV-II	80	53.11	0.40	-	-	-	-	21.94
	2	1410	-2.31%	70	All	All	Car	80	26.03	0.17	-	-	-	-	36.93
	"	"	"	"	"	"	LCV	80	20.85	0.18	-	-	-	-	29.66
	"	"	"	"	"	"	MCV	70	37.99	0.17	-	-	-	-	53.80
	"	"	"	"	"	"	HCV-I	70	46.03	0.33	-	-	-	-	65.37
	"	"	"	"	"	"	HCV-II	70	50.61	0.40	-	-	-	-	71.92
	3	500	3.09%	70	All	All	Car	80	29.47	0.17	-	-	-	-	14.82
	"	"	"	"	"	"	LCV	80	25.39	0.18	-	-	-	-	12.78
	"	"	"	"	"	"	MCV	70	47.56	0.17	-	-	-	-	23.86
	"	"	"	"	"	"	HCV-I	70	65.32	0.33	-	-	-	-	32.83
	"	"	"	"	"	"	HCV-II	70	86.67	0.40	-	-	-	-	43.54
REALIGNMENT OPTIONS - Northbound (Continued)							AADT =	5044							
	4	680	-5.24%	70	All	All	Car	80	25.19	0.17	-	-	-	-	17.25
	"	"	"	"	"	"	LCV	80	19.66	0.18	-	-	-	-	13.49
	"	"	"	"	"	"	MCV	56	40.46	0.17	-	-	-	-	27.63
	"	"	"	"	"	"	HCV-I	56	53.54	0.33	-	-	-	-	36.63
	"	"	"	"	"	"	HCV-II	56	68.19	0.40	-	-	-	-	46.64
	5	400	4.43%	70	All	All	Car	80	30.33	0.17	-	-	-	-	12.20
	"	"	"	"	"	"	LCV	80	26.42	0.18	-	-	-	-	10.64
	"	"	"	"	"	"	MCV	24	50.31	0.17	-	-	-	-	20.19
	"	"	"	"	"	"	HCV-I	24	71.38	0.33	-	-	-	-	28.68
	"	"	"	"	"	"	HCV-II	24	99.47	0.40	-	-	-	-	39.95
	6	980	10.00%	70	All	All	Car	80	34.56	0.17	-	-	-	-	34.04
	"	"	"	"	"	"	LCV	80	30.94	0.18	-	-	-	-	30.50
	"	"	"	"	"	"	MCV	23	61.86	0.17	-	-	-	-	60.79
	"	"	"	"	"	"	HCV-I	23	96.08	0.33	-	-	-	-	94.48
	"	"	"	"	"	"	HCV-II	23	150.56	0.40	-	-	-	-	147.94
REALIGNMENT OPTIONS - Northbound (Continued)							AADT =	5044							
	7	400	8.34%	70	All	All	Car	80	33.23	0.17	-	-	-	-	13.36
	"	"	"	"	"	"	LCV	80	29.56	0.18	-	-	-	-	11.90
	"	"	"	"	"	"	MCV	31	57.60	0.17	-	-	-	-	23.11
	"	"	"	"	"	"	HCV-I	31	87.44	0.33	-	-	-	-	35.11
	"	"	"	"	"	"	HCV-II	31	133.59	0.40	-	-	-	-	53.60
	8	900	3.18%	70	All	All	Car	90	29.80	0.17	-	-	-	-	26.97
	"	"	"	"	"	"	LCV	90	26.07	0.18	-	-	-	-	23.63
	"	"	"	"	"	"	MCV	61	47.20	0.17	-	-	-	-	42.63
	"	"	"	"	"	"	HCV-I	61	64.92	0.33	-	-	-	-	58.72
	"	"	"	"	"	"	HCV-II	61	86.66	0.40	-	-	-	-	78.35

VEHICLE OPERATING COSTS A: WORKSHEET A5.1

Option (1)	Section/ Movement (2)	Section Length (m) (3)	Average Gradient (%) (4)	Surface Roughness counts/km (5)	Period From (6)	Period To (6)	Vehicle Type (7)	Section Speed (km/h) (8)	Base Cost (cents/km) (9)	Roughness Cost (cents/km) (10)	Speed Changes & Stops Min Speed (km/h) (11)	Speed Changes & Stops Add. Cost (cents) (12)	Queuing Delay Time (mins) (13)	Queuing Delay Fuel (cents) (14)	Section Cost (cents) (15)
DO MINIMUM - Southbound							AADT =	5464	(Yr 2)						
	1	620	1.13%	70	All	All	Car	78	28.12	0.17	80-60-80	0.5	-	-	18.04
	"	"	"	"	"	"	LCV	78	23.84	0.18	80-60-80	0.4	-	-	15.29
	"	"	"	"	"	"	MCV	78	44.02	0.17	80-55-80	2.0	-	-	29.40
	"	"	"	"	"	"	HCV-I	78	57.54	0.33	80-55-80	4.5	-	-	40.38
	"	"	"	"	"	"	HCV-II	78	69.76	0.40	80-55-80	10.3	-	-	53.80
	2	1410	2.31%	70	All	All	Car	63	28.87	0.17	65-50-65	0.3	-	-	41.24
	"	"	"	"	"	"	LCV	63	24.06	0.18	65-50-65	0.2	-	-	34.38
	"	"	"	"	"	"	MCV	63	45.50	0.17	65-45-65	1.5	-	-	65.89
	"	"	"	"	"	"	HCV-I	63	61.18	0.33	65-45-65	3.1	-	-	89.82
	"	"	"	"	"	"	HCV-II	63	78.87	0.40	65-45-65	7.0	-	-	118.77
	3	500	-3.09%	90	All	All	Car	62	25.71	1.38	65-50-65	0.3	-	-	13.84
	"	"	"	"	"	"	LCV	62	20.03	1.47	65-50-65	0.2	-	-	10.95
	"	"	"	"	"	"	MCV	50	38.35	2.74	-	-	-	-	20.55
	"	"	"	"	"	"	HCV-I	50	47.57	5.66	-	-	-	-	26.62
	"	"	"	"	"	"	HCV-II	50	54.39	5.65	-	-	-	-	30.02
DO MINIMUM - Southbound (Continued)							AADT =	5464	(Yr 2)						
	4	680	5.24%	87	All	All	Car	62	30.83	1.16	-	-	-	-	21.75
	"	"	"	"	"	"	LCV	62	26.16	1.23	-	-	-	-	18.62
	"	"	"	"	"	"	MCV	45	50.91	2.15	-	-	-	-	36.08
	"	"	"	"	"	"	HCV-I	45	73.25	4.35	-	-	-	-	52.77
	"	"	"	"	"	"	HCV-II	45	104.63	4.43	-	-	-	-	74.16
	5	400	-4.43%	86	All	All	Car	58	25.68	1.08	60-40-60	0.4	-	-	11.11
	"	"	"	"	"	"	LCV	58	19.95	1.15	60-40-60	0.4	-	-	8.84
	"	"	"	"	"	"	MCV	35	41.21	1.95	-	-	-	-	17.26
	"	"	"	"	"	"	HCV-I	35	53.88	3.92	-	-	-	-	23.12
	"	"	"	"	"	"	HCV-II	35	65.77	4.02	-	-	-	-	27.92
	6	980	-10.00%	86	All	All	Car	58	25.68	1.08	60-50-60	0.2	-	-	26.43
	"	"	"	"	"	"	LCV	58	19.95	1.15	60-50-60	0.1	-	-	20.78
	"	"	"	"	"	"	MCV	40	58.69	1.95	-	-	-	-	59.43
	"	"	"	"	"	"	HCV-I	40	97.06	3.92	-	-	-	-	98.96
	"	"	"	"	"	"	HCV-II	40	152.21	4.02	-	-	-	-	153.10
DO MINIMUM - Southbound (Continued)							AADT =	5464	(Yr 2)						
	7	400	-8.34%	86	All	All	Car	58	25.68	1.08	60-40-60	0.4	-	-	11.10
	"	"	"	"	"	"	LCV	58	19.95	1.15	60-40-60	0.4	-	-	8.84
	"	"	"	"	"	"	MCV	50	49.81	1.95	50-35-50	0.9	-	-	21.60
	"	"	"	"	"	"	HCV-I	50	76.46	3.92	50-35-50	2.0	-	-	34.15
	"	"	"	"	"	"	HCV-II	50	113.89	4.02	50-35-50	4.0	-	-	51.16
	8	1110	-3.18%	86	All	All	Car	74	25.57	1.08	-	-	-	-	29.58
	"	"	"	"	"	"	LCV	74	20.14	1.15	-	-	-	-	23.64
	"	"	"	"	"	"	MCV	74	37.61	1.95	75-65-75	0.7	-	-	44.61
	"	"	"	"	"	"	HCV-I	74	45.93	3.92	75-65-75	1.7	-	-	57.03
	"	"	"	"	"	"	HCV-II	74	51.98	4.02	75-65-75	4.0	-	-	66.16

Option	Section/ Movement	Section Length (m)	Average Gradient (%)	Surface Roughness counts/km	Period From	Period To	Vehicle Type	Section Speed (km/h)	Base Cost (cents/km)	Roughness Cost (cents/km)	Speed Changes & Stops Min Speed (km/h)	Speed Changes & Stops Add. Cost (cents)	Queuing Delay Time (mins)	Queuing Delay Fuel (cents)	Section Cost (cents)
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
DO MINIMUM - Northbound							AADT =	5464	(Yr 2)						
	1	620	-1.13%	72	All	All	Car	76	26.65	0.23	80-60-80	0.5	-	-	17.17
	"	"	"	"	"	"	LCV	76	21.57	0.25	80-60-80	0.4	-	-	13.93
	"	"	"	"	"	"	MCV	76	40.85	0.23	80-55-80	2.0	-	-	27.47
	"	"	"	"	"	"	HCV-I	76	50.07	0.46	80-55-80	4.5	-	-	35.83
	"	"	"	"	"	"	HCV-II	76	52.59	0.56	80-55-80	10.3	-	-	43.25
	2	1410	-2.31%	72	All	All	Car	61	26.04	0.23	65-50-65	0.3	-	-	37.34
	"	"	"	"	"	"	LCV	61	20.50	0.25	65-50-65	0.2	-	-	29.45
	"	"	"	"	"	"	MCV	61	37.87	0.23	65-45-65	1.5	-	-	55.23
	"	"	"	"	"	"	HCV-I	61	46.18	0.46	65-45-65	3.1	-	-	68.86
	"	"	"	"	"	"	HCV-II	61	51.26	0.56	65-45-65	7.0	-	-	80.06
	3	500	3.09%	83	All	All	Car	65	29.35	0.87	65-50-65	0.3	-	-	15.41
	"	"	"	"	"	"	LCV	65	24.69	0.92	65-50-65	0.2	-	-	13.00
	"	"	"	"	"	"	MCV	65	47.24	1.35	65-45-65	1.5	-	-	25.80
	"	"	"	"	"	"	HCV-I	65	64.84	2.61	65-45-65	3.1	-	-	36.82
	"	"	"	"	"	"	HCV-II	65	86.19	2.80	65-45-65	7.0	-	-	51.49
DO MINIMUM - Northbound (Continued)							AADT =	5464	(Yr 2)						
	4	680	-5.24%	83	All	All	Car	65	25.47	0.87	-	-	-	-	17.91
	"	"	"	"	"	"	LCV	65	19.80	0.92	-	-	-	-	14.09
	"	"	"	"	"	"	MCV	56	40.46	1.35	-	-	-	-	28.44
	"	"	"	"	"	"	HCV-I	56	53.54	2.61	-	-	-	-	38.18
	"	"	"	"	"	"	HCV-II	56	68.19	2.80	-	-	-	-	48.27
	5	400	4.43%	95	All	All	Car	52	30.42	1.77	-	-	-	-	12.88
	"	"	"	"	"	"	LCV	52	25.28	1.88	-	-	-	-	10.87
	"	"	"	"	"	"	MCV	24	50.31	3.74	-	-	-	-	21.62
	"	"	"	"	"	"	HCV-I	24	71.38	7.85	-	-	-	-	31.69
	"	"	"	"	"	"	HCV-II	24	99.47	7.68	-	-	-	-	42.86
	6	980	10.00%	95	All	All	Car	52	33.91	1.77	55-40-55	0.3	-	-	35.26
	"	"	"	"	"	"	LCV	52	29.44	1.88	55-40-55	0.3	-	-	31.00
	"	"	"	"	"	"	MCV	23	61.86	3.74	-	-	-	-	64.29
	"	"	"	"	"	"	HCV-I	23	96.08	7.85	-	-	-	-	101.85
	"	"	"	"	"	"	HCV-II	23	150.56	7.68	-	-	-	-	155.07
DO MINIMUM - Northbound (Continued)							AADT =	5464	(Yr 2)						
	7	400	8.34%	95	All	All	Car	52	32.86	1.77	55-40-55	0.3	-	-	14.15
	"	"	"	"	"	"	LCV	52	28.17	1.88	55-40-55	0.3	-	-	12.32
	"	"	"	"	"	"	MCV	31	57.60	3.74	-	-	-	-	24.54
	"	"	"	"	"	"	HCV-I	31	87.44	7.85	-	-	-	-	38.12
	"	"	"	"	"	"	HCV-II	31	133.59	7.68	-	-	-	-	56.51
	8	1110	3.18%	95	All	All	Car	71	29.42	1.77	-	-	-	-	34.62
	"	"	"	"	"	"	LCV	71	25.00	1.88	-	-	-	-	29.84
	"	"	"	"	"	"	MCV	61	47.20	3.74	-	-	-	-	56.54
	"	"	"	"	"	"	HCV-I	61	64.92	7.85	-	-	-	-	80.77
	"	"	"	"	"	"	HCV-II	61	86.66	7.68	-	-	-	-	104.71

VEHICLE OPERATING COSTS A: WORKSHEET A5.1

Option	Section/ Movement	Section Length (m)	Average Gradient (%)	Surface Roughness counts/km	Period		Vehicle Type	Section Speed (km/h)	Base Cost (cents/km)	Roughness Cost (cents/km)	Speed Changes & Stops		Queuing Delay		Section Cost (cents)
					From	To					Min Speed (km/h)	Add. Cost (cents)	Time (mins)	Fuel (cents)	
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
REALIGNMENT OPTIONS - Southbound							AADT =	5464	(Yr 2)						
	1	410	1.13%	70	All	All	Car	90	28.40	0.17	-	-	-	-	11.71
	"	"	"	"	"	"	LCV	90	24.51	0.18	-	-	-	-	10.12
	"	"	"	"	"	"	MCV	78	44.02	0.17	-	-	-	-	18.12
	"	"	"	"	"	"	HCV-I	78	57.54	0.33	-	-	-	-	23.73
	"	"	"	"	"	"	HCV-II	78	69.76	0.40	-	-	-	-	28.77
	2	1410	2.31%	70	All	All	Car	80	28.93	0.17	-	-	-	-	41.04
	"	"	"	"	"	"	LCV	80	24.80	0.18	-	-	-	-	35.23
	"	"	"	"	"	"	MCV	63	45.50	0.17	-	-	-	-	64.39
	"	"	"	"	"	"	HCV-I	63	61.18	0.33	-	-	-	-	86.72
	"	"	"	"	"	"	HCV-II	63	78.87	0.40	-	-	-	-	111.77
	3	500	-3.09%	70	All	All	Car	80	25.65	0.17	-	-	-	-	12.91
	"	"	"	"	"	"	LCV	80	20.38	0.18	-	-	-	-	10.28
	"	"	"	"	"	"	MCV	65	37.70	0.17	-	-	-	-	18.94
	"	"	"	"	"	"	HCV-I	65	46.27	0.33	-	-	-	-	23.30
	"	"	"	"	"	"	HCV-II	65	52.51	0.40	-	-	-	-	26.45
REALIGNMENT OPTIONS - Southbound (Continued)							AADT =	5464	(Yr 2)						
	4	680	5.24%	70	All	All	Car	80	30.89	0.17	-	-	-	-	21.12
	"	"	"	"	"	"	LCV	80	27.05	0.18	-	-	-	-	18.52
	"	"	"	"	"	"	MCV	54	51.17	0.17	-	-	-	-	34.91
	"	"	"	"	"	"	HCV-I	54	73.64	0.33	-	-	-	-	50.30
	"	"	"	"	"	"	HCV-II	54	104.73	0.40	-	-	-	-	71.49
	5	400	-4.43%	70	All	All	Car	80	25.27	0.17	-	-	-	-	10.18
	"	"	"	"	"	"	LCV	80	19.83	0.18	-	-	-	-	8.00
	"	"	"	"	"	"	MCV	51	39.65	0.17	-	-	-	-	15.93
	"	"	"	"	"	"	HCV-I	51	51.08	0.33	-	-	-	-	20.56
	"	"	"	"	"	"	HCV-II	51	62.22	0.40	-	-	-	-	25.05
	6	980	-10.00%	70	All	All	Car	80	25.16	0.17	-	-	-	-	24.82
	"	"	"	"	"	"	LCV	80	19.55	0.18	-	-	-	-	19.34
	"	"	"	"	"	"	MCV	78	51.38	0.17	-	-	-	-	50.52
	"	"	"	"	"	"	HCV-I	78	83.69	0.33	-	-	-	-	82.34
	"	"	"	"	"	"	HCV-II	78	136.98	0.40	-	-	-	-	134.63
REALIGNMENT OPTIONS - Southbound (Continued)							AADT =	5464	(Yr 2)						
	7	400	-8.34%	70	All	All	Car	80	25.16	0.17	-	-	-	-	10.13
	"	"	"	"	"	"	LCV	80	19.55	0.18	-	-	-	-	7.89
	"	"	"	"	"	"	MCV	80	45.13	0.17	-	-	-	-	18.12
	"	"	"	"	"	"	HCV-I	80	67.74	0.33	-	-	-	-	27.23
	"	"	"	"	"	"	HCV-II	80	103.73	0.40	-	-	-	-	41.65
	8	900	-3.18%	70	All	All	Car	90	25.84	0.17	-	-	-	-	23.41
	"	"	"	"	"	"	LCV	90	20.79	0.18	-	-	-	-	18.87
	"	"	"	"	"	"	MCV	80	37.78	0.17	-	-	-	-	34.16
	"	"	"	"	"	"	HCV-I	80	45.75	0.33	-	-	-	-	41.47
	"	"	"	"	"	"	HCV-II	80	51.43	0.40	-	-	-	-	46.65

Option	Section/ Movement	Section Length (m)	Average Gradient (%)	Surface Roughness counts/km	Period From	Period To	Vehicle Type	Section Speed (km/h)	Base Cost (cents/km)	Roughness Cost (cents/km)	Speed Changes & Stops: Min Speed (km/h)	Speed Changes & Stops: Add. Cost (cents)	Queuing Delay: Time (mins)	Queuing Delay: Fuel (cents)	Section Cost (cents)
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
REALIGNMENT OPTIONS - Northbound							AADT =	5464	(Yr 2)						
	1	410	-1.13%	70	All	All	Car	90	26.91	0.17	-	-	-	-	11.10
	"	"	"	"	"	"	LCV	90	22.13	0.18	-	-	-	-	9.15
	"	"	"	"	"	"	MCV	80	41.51	0.17	-	-	-	-	17.09
	"	"	"	"	"	"	HCV-I	80	50.85	0.33	-	-	-	-	20.99
	"	"	"	"	"	"	HCV-II	80	53.11	0.40	-	-	-	-	21.94
	2	1410	-2.31%	70	All	All	Car	80	26.03	0.17	-	-	-	-	36.93
	"	"	"	"	"	"	LCV	80	20.85	0.18	-	-	-	-	29.66
	"	"	"	"	"	"	MCV	70	37.99	0.17	-	-	-	-	53.80
	"	"	"	"	"	"	HCV-I	70	46.03	0.33	-	-	-	-	65.37
	"	"	"	"	"	"	HCV-II	70	50.61	0.40	-	-	-	-	71.92
	3	500	3.09%	70	All	All	Car	80	29.47	0.17	-	-	-	-	14.82
	"	"	"	"	"	"	LCV	80	25.39	0.18	-	-	-	-	12.78
	"	"	"	"	"	"	MCV	70	47.56	0.17	-	-	-	-	23.86
	"	"	"	"	"	"	HCV-I	70	65.32	0.33	-	-	-	-	32.83
	"	"	"	"	"	"	HCV-II	70	86.67	0.40	-	-	-	-	43.54
REALIGNMENT OPTIONS - Northbound (Continued)							AADT =	5464	(Yr 2)						
	4	680	-5.24%	70	All	All	Car	80	25.19	0.17	-	-	-	-	17.25
	"	"	"	"	"	"	LCV	80	19.66	0.18	-	-	-	-	13.49
	"	"	"	"	"	"	MCV	56	40.46	0.17	-	-	-	-	27.63
	"	"	"	"	"	"	HCV-I	56	53.54	0.33	-	-	-	-	36.63
	"	"	"	"	"	"	HCV-II	56	68.19	0.40	-	-	-	-	46.64
	5	400	4.43%	70	All	All	Car	80	30.33	0.17	-	-	-	-	12.20
	"	"	"	"	"	"	LCV	80	26.42	0.18	-	-	-	-	10.64
	"	"	"	"	"	"	MCV	24	50.31	0.17	-	-	-	-	20.19
	"	"	"	"	"	"	HCV-I	24	71.38	0.33	-	-	-	-	28.68
	"	"	"	"	"	"	HCV-II	24	99.47	0.40	-	-	-	-	39.95
	6	980	10.00%	70	All	All	Car	80	34.56	0.17	-	-	-	-	34.04
	"	"	"	"	"	"	LCV	80	30.94	0.18	-	-	-	-	30.50
	"	"	"	"	"	"	MCV	23	61.86	0.17	-	-	-	-	60.79
	"	"	"	"	"	"	HCV-I	23	96.08	0.33	-	-	-	-	94.48
	"	"	"	"	"	"	HCV-II	23	150.56	0.40	-	-	-	-	147.94
REALIGNMENT OPTIONS - Northbound (Continued)							AADT =	5464	(Yr 2)						
	7	400	8.34%	70	All	All	Car	80	33.23	0.17	-	-	-	-	13.36
	"	"	"	"	"	"	LCV	80	29.56	0.18	-	-	-	-	11.90
	"	"	"	"	"	"	MCV	31	57.60	0.17	-	-	-	-	23.11
	"	"	"	"	"	"	HCV-I	31	87.44	0.33	-	-	-	-	35.11
	"	"	"	"	"	"	HCV-II	31	133.59	0.40	-	-	-	-	53.60
	8	900	3.18%	70	All	All	Car	90	29.80	0.17	-	-	-	-	26.97
	"	"	"	"	"	"	LCV	90	26.07	0.18	-	-	-	-	23.63
	"	"	"	"	"	"	MCV	61	47.20	0.17	-	-	-	-	42.63
	"	"	"	"	"	"	HCV-I	61	64.92	0.33	-	-	-	-	58.72
	"	"	"	"	"	"	HCV-II	61	86.66	0.40	-	-	-	-	78.35

VEHICLE OPERATING COSTS B: WORKSHEET A5.2

Option	Section/ Movement	Time Units	Period From	Period To	Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughnes (cents)
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
DO MINIMUM - Southbound			AADT = 5044							
	1	Days	All	All	365	Car	1942	18.04	$127,865	17.93
	"	"	"	"	"	LCV	227	15.29	$12,669	15.18
	"	"	"	"	"	MCV	126	29.40	$13,530	29.29
	"	"	"	"	"	HCV-I	101	40.38	$14,868	40.18
	"	"	"	"	"	HCV-II	126	53.80	$24,763	53.55
	2	Days	All	All	365	Car	1942	41.24	$292,314	41.00
	"	"	"	"	"	LCV	227	34.38	$28,479	34.12
	"	"	"	"	"	MCV	126	65.89	$30,327	65.65
	"	"	"	"	"	HCV-I	101	89.82	$33,074	89.36
	"	"	"	"	"	HCV-II	126	118.77	$54,666	118.21
	3	Days	All	All	365	Car	1942	13.84	$98,128	13.15
	"	"	"	"	"	LCV	227	10.95	$9,070	10.21
	"	"	"	"	"	MCV	126	20.55	$9,457	19.18
	"	"	"	"	"	HCV-I	101	26.62	$9,801	23.79
	"	"	"	"	"	HCV-II	126	30.02	$13,817	27.19
DO MINIMUM - Southbound (Continued)			AADT = 5044							
	4	Days	All	All	365	Car	1942	21.75	$154,186	20.97
	"	"	"	"	"	LCV	227	18.62	$15,429	17.79
	"	"	"	"	"	MCV	126	36.08	$16,606	34.62
	"	"	"	"	"	HCV-I	101	52.77	$19,431	49.81
	"	"	"	"	"	HCV-II	126	74.16	$34,132	71.15
	5	Days	All	All	365	Car	1942	11.11	$78,728	10.67
	"	"	"	"	"	LCV	227	8.84	$7,324	8.38
	"	"	"	"	"	MCV	126	17.26	$7,946	16.49
	"	"	"	"	"	HCV-I	101	23.12	$8,512	21.55
	"	"	"	"	"	HCV-II	126	27.92	$12,849	26.31
	6	Days	All	All	365	Car	1942	26.43	$187,315	25.36
	"	"	"	"	"	LCV	227	20.78	$17,212	19.65
	"	"	"	"	"	MCV	126	59.43	$27,351	57.52
	"	"	"	"	"	HCV-I	101	98.96	$36,437	95.12
	"	"	"	"	"	HCV-II	126	153.10	$70,468	149.17
DO MINIMUM - Southbound (Continued)			AADT = 5044							
	7	Days	All	All	365	Car	1942	11.10	$78,712	10.67
	"	"	"	"	"	LCV	227	8.84	$7,323	8.38
	"	"	"	"	"	MCV	126	21.60	$9,942	20.82
	"	"	"	"	"	HCV-I	101	34.15	$12,575	32.59
	"	"	"	"	"	HCV-II	126	51.16	$23,548	49.55
	8	Days	All	All	365	Car	1942	29.58	$209,696	28.38
	"	"	"	"	"	LCV	227	23.64	$19,582	22.36
	"	"	"	"	"	MCV	126	44.61	$20,532	42.45
	"	"	"	"	"	HCV-I	101	57.03	$20,997	52.68
	"	"	"	"	"	HCV-II	126	66.16	$30,452	61.70
	Total Annual VOC - Southbound (Car, LCV, MCV)							=	**$1,479,725**	
	Total Annual VOC - Southbound (HCV-I, HCV-II)								**$420,391**	1,900,116
Total Annual VOC - Southbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,436,191	
Total Annual VOC - Southbound (HCV-I, HCV-II) (excluding Roughness Costs)									$405,441	1,841,633
=> Total Annual Carbon Dioxide Emission Cost - Southbound (Car, LCV, Mcv)								=	**$64,629**	
=> Total Annual Carbon Dioxide Emission Cost - Southbound (HCV-I, HCV-II)									**$18,245**	82,873

VEHICLE OPERATING COSTS B: WORKSHEET A5.2

Option	Section/ Movement	Time Units	Period		Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughness) (cents)
			From	To						
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
DO MINIMUM - Northbound			AADT = 5044							
	1	Days	All	All	365	Car	1942	17.17	$121,691	17.02
	"	"	"	"	"	LCV	227	13.93	$11,538	13.77
	"	"	"	"	"	MCV	126	27.47	$12,646	27.33
	"	"	"	"	"	HCV-I	101	35.83	$13,191	35.54
	"	"	"	"	"	HCV-II	126	43.25	$19,907	42.91
	2	Days	All	All	365	Car	1942	37.34	$264,672	37.01
	"	"	"	"	"	LCV	227	29.45	$24,399	29.10
	"	"	"	"	"	MCV	126	55.23	$25,421	54.90
	"	"	"	"	"	HCV-I	101	68.86	$25,354	68.21
	"	"	"	"	"	HCV-II	126	80.06	$36,848	79.27
	3	Days	All	All	365	Car	1942	15.41	$109,211	14.97
	"	"	"	"	"	LCV	227	13.00	$10,772	12.54
	"	"	"	"	"	MCV	126	25.80	$11,873	25.12
	"	"	"	"	"	HCV-I	101	36.82	$13,558	35.52
	"	"	"	"	"	HCV-II	126	51.49	$23,700	50.09
DO MINIMUM - Northbound (Continued)			AADT = 5044							
	4	Days	All	All	365	Car	1942	17.91	$126,937	17.32
	"	"	"	"	"	LCV	227	14.09	$11,670	13.46
	"	"	"	"	"	MCV	126	28.44	$13,088	27.52
	"	"	"	"	"	HCV-I	101	38.18	$14,059	36.41
	"	"	"	"	"	HCV-II	126	48.27	$22,216	46.37
	5	Days	All	All	365	Car	1942	12.88	$91,265	12.17
	"	"	"	"	"	LCV	227	10.87	$9,002	10.11
	"	"	"	"	"	MCV	126	21.62	$9,951	20.12
	"	"	"	"	"	HCV-I	101	31.69	$11,669	28.55
	"	"	"	"	"	HCV-II	126	42.86	$19,727	39.79
	6	Days	All	All	365	Car	1942	35.26	$249,943	33.53
	"	"	"	"	"	LCV	227	31.00	$25,681	29.16
	"	"	"	"	"	MCV	126	64.29	$29,591	60.63
	"	"	"	"	"	HCV-I	101	101.85	$37,504	94.16
	"	"	"	"	"	HCV-II	126	155.07	$71,375	147.55
DO MINIMUM - Northbound (Continued)			AADT = 5044							
	7	Days	All	All	365	Car	1942	14.15	$100,311	13.44
	"	"	"	"	"	LCV	227	12.32	$10,207	11.57
	"	"	"	"	"	MCV	126	24.54	$11,293	23.04
	"	"	"	"	"	HCV-I	101	38.12	$14,035	34.98
	"	"	"	"	"	HCV-II	126	56.51	$26,009	53.44
	8	Days	All	All	365	Car	1942	34.62	$245,421	32.66
	"	"	"	"	"	LCV	227	29.84	$24,719	27.75
	"	"	"	"	"	MCV	126	56.54	$26,025	52.39
	"	"	"	"	"	HCV-I	101	80.77	$29,742	72.06
	"	"	"	"	"	HCV-II	126	104.71	$48,196	96.19
	Total Annual VOC - Northbound (Car, LCV, MCV)							=	**$1,577,329**	
	Total Annual VOC - Northbound (HCV-I, HCV-II)								**$427,091**	2,004,420
Total Annual VOC - Northbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,518,716	
Total Annual VOC - Northbound (HCV-I, HCV-II) (excluding Roughness Costs)									$405,007	1,923,724
=> Total Annual Carbon Dioxide Emission Cost - Northbound (Car, LCV, Mcv)								=	**$68,342**	
=> Total Annual Carbon Dioxide Emission Cost - Northbound (HCV-I, HCV-II)									**$18,225**	86,568

VEHICLE OPERATING COSTS B: WORKSHEET A5.2

Option	Section/ Movement	Time Units	Period From	Period To	Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughnes (cents)
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
REALIGNMENT OPTIONS - Southbound			AADT = 5044							
	1	Days	All	All	365	Car	1942	11.71	$83,033	11.64
	"	"	"	"	"	LCV	227	10.12	$8,386	10.05
	"	"	"	"	"	MCV	126	18.12	$8,339	18.05
	"	"	"	"	"	HCV-I	101	23.73	$8,737	23.59
	"	"	"	"	"	HCV-II	126	28.77	$13,241	28.60
	2	Days	All	All	365	Car	1942	41.04	$290,870	40.80
	"	"	"	"	"	LCV	227	35.23	$29,183	34.97
	"	"	"	"	"	MCV	126	64.39	$29,637	64.15
	"	"	"	"	"	HCV-I	101	86.72	$31,933	86.26
	"	"	"	"	"	HCV-II	126	111.77	$51,444	111.21
	3	Days	All	All	365	Car	1942	12.91	$91,502	12.82
	"	"	"	"	"	LCV	227	10.28	$8,515	10.19
	"	"	"	"	"	MCV	126	18.94	$8,716	18.85
	"	"	"	"	"	HCV-I	101	23.30	$8,580	23.14
	"	"	"	"	"	HCV-II	126	26.45	$12,175	26.25
REALIGNMENT OPTIONS - Southbound (Continu			AADT = 5044							
	4	Days	All	All	365	Car	1942	21.12	$149,694	21.00
	"	"	"	"	"	LCV	227	18.52	$15,340	18.39
	"	"	"	"	"	MCV	126	34.91	$16,067	34.79
	"	"	"	"	"	HCV-I	101	50.30	$18,521	50.08
	"	"	"	"	"	HCV-II	126	71.49	$32,902	71.21
	5	Days	All	All	365	Car	1942	10.18	$72,140	10.11
	"	"	"	"	"	LCV	227	8.00	$6,631	7.93
	"	"	"	"	"	MCV	126	15.93	$7,330	15.86
	"	"	"	"	"	HCV-I	101	20.56	$7,572	20.43
	"	"	"	"	"	HCV-II	126	25.05	$11,528	24.89
	6	Days	All	All	365	Car	1942	24.82	$175,950	24.66
	"	"	"	"	"	LCV	227	19.34	$16,019	19.16
	"	"	"	"	"	MCV	126	50.52	$23,251	50.35
	"	"	"	"	"	HCV-I	101	82.34	$30,319	82.02
	"	"	"	"	"	HCV-II	126	134.63	$61,967	134.24
REALIGNMENT OPTIONS - Southbound (Continu			AADT = 5044							
	7	Days	All	All	365	Car	1942	10.13	$71,816	10.06
	"	"	"	"	"	LCV	227	7.89	$6,538	7.82
	"	"	"	"	"	MCV	126	18.12	$8,340	18.05
	"	"	"	"	"	HCV-I	101	27.23	$10,025	27.10
	"	"	"	"	"	HCV-II	126	41.65	$19,171	41.49
	8	Days	All	All	365	Car	1942	23.41	$165,919	23.26
	"	"	"	"	"	LCV	227	18.87	$15,633	18.71
	"	"	"	"	"	MCV	126	34.16	$15,722	34.01
	"	"	"	"	"	HCV-I	101	41.47	$15,271	41.18
	"	"	"	"	"	HCV-II	126	46.65	$21,469	46.29
	Total Annual VOC - Southbound (Car, LCV, MCV)							=	**$1,324,572**	
	Total Annual VOC - Southbound (HCV-I, HCV-II)								**$354,855**	1,679,428
Total Annual VOC - Southbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,316,437	
Total Annual VOC - Southbound (HCV-I, HCV-II) (excluding Roughness Costs)									$353,120	1,669,556
=> Total Annual Carbon Dioxide Emission Cost - Southbound (Car, LCV, Mcv)								=	**$59,240**	
=> Total Annual Carbon Dioxide Emission Cost - Southbound (HCV-I, HCV-II)									**$15,890**	75,130

VEHICLE OPERATING COSTS B: WORKSHEET A5.2

Option	Section/ Movement	Time Units	Period		Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughnes (cents)
			From	To						
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
REALIGNMENT OPTIONS - Northbound			AADT = 5044							
	1	Days	All	All	365	Car	1942	11.10	$78,693	11.03
	"	"	"	"	"	LCV	227	9.15	$7,578	9.07
	"	"	"	"	"	MCV	126	17.09	$7,865	17.02
	"	"	"	"	"	HCV-I	101	20.99	$7,727	20.85
	"	"	"	"	"	HCV-II	126	21.94	$10,099	21.78
	2	Days	All	All	365	Car	1942	36.93	$261,798	36.70
	"	"	"	"	"	LCV	227	29.66	$24,572	29.41
	"	"	"	"	"	MCV	126	53.80	$24,763	53.56
	"	"	"	"	"	HCV-I	101	65.37	$24,069	64.90
	"	"	"	"	"	HCV-II	126	71.92	$33,104	71.36
	3	Days	All	All	365	Car	1942	14.82	$105,034	14.73
	"	"	"	"	"	LCV	227	12.78	$10,591	12.69
	"	"	"	"	"	MCV	126	23.86	$10,984	23.78
	"	"	"	"	"	HCV-I	101	32.83	$12,087	32.66
	"	"	"	"	"	HCV-II	126	43.54	$20,038	43.34
REALIGNMENT OPTIONS - Northbound (Continu			AADT = 5044							
	4	Days	All	All	365	Car	1942	17.25	$122,234	17.13
	"	"	"	"	"	LCV	227	13.49	$11,176	13.37
	"	"	"	"	"	MCV	126	27.63	$12,718	27.52
	"	"	"	"	"	HCV-I	101	36.63	$13,489	36.41
	"	"	"	"	"	HCV-II	126	46.64	$21,466	46.37
	5	Days	All	All	365	Car	1942	12.20	$86,469	12.13
	"	"	"	"	"	LCV	227	10.64	$8,813	10.57
	"	"	"	"	"	MCV	126	20.19	$9,294	20.12
	"	"	"	"	"	HCV-I	101	28.68	$10,562	28.55
	"	"	"	"	"	HCV-II	126	39.95	$18,387	39.79
	6	Days	All	All	365	Car	1942	34.04	$241,246	33.87
	"	"	"	"	"	LCV	227	30.50	$25,267	30.32
	"	"	"	"	"	MCV	126	60.79	$27,981	60.63
	"	"	"	"	"	HCV-I	101	94.48	$34,790	94.16
	"	"	"	"	"	HCV-II	126	147.94	$68,091	147.55
REALIGNMENT OPTIONS - Northbound (Continu			AADT = 5044							
	7	Days	All	All	365	Car	1942	13.36	$94,693	13.29
	"	"	"	"	"	LCV	227	11.90	$9,856	11.82
	"	"	"	"	"	MCV	126	23.11	$10,636	23.04
	"	"	"	"	"	HCV-I	101	35.11	$12,928	34.98
	"	"	"	"	"	HCV-II	126	53.60	$24,669	53.44
	8	Days	All	All	365	Car	1942	26.97	$191,197	26.82
	"	"	"	"	"	LCV	227	23.63	$19,574	23.46
	"	"	"	"	"	MCV	126	42.63	$19,623	42.48
	"	"	"	"	"	HCV-I	101	58.72	$21,623	58.43
	"	"	"	"	"	HCV-II	126	78.35	$36,062	77.99
	Total Annual VOC - Northbound (Car, LCV, MCV)							=	**$1,422,655**	
	Total Annual VOC - Northbound (HCV-I, HCV-II)								**$369,189**	1,791,844
Total Annual VOC - Northbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,414,519	
Total Annual VOC - Northbound (HCV-I, HCV-II) (excluding Roughness Costs)									$367,453	1,781,973
=> Total Annual Carbon Dioxide Emission Cost - Northbound (Car, LCV, Mcv)								=	**$63,653**	
=> Total Annual Carbon Dioxide Emission Cost - Northbound (HCV-I, HCV-II)									**$16,535**	80,189

VEHICLE OPERATING COSTS B: WORKSHEET A5.2

Option	Section/ Movement	Time Units	Period From	Period To	Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughnes (cents)
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
DO MINIMUM - Southbound				AADT = 5464		(Yr 2)				
	1	Days	All	All	365	Car	2082	18.04	$137,087	17.93
	"	"	"	"	"	LCV	243	15.29	$13,563	15.18
	"	"	"	"	"	MCV	135	29.40	$14,485	29.29
	"	"	"	"	"	HCV-I	121	40.38	$17,834	40.18
	"	"	"	"	"	HCV-II	151	53.80	$29,653	53.55
	2	Days	All	All	365	Car	2082	41.24	$313,397	41.00
	"	"	"	"	"	LCV	243	34.38	$30,489	34.12
	"	"	"	"	"	MCV	135	65.89	$32,468	65.65
	"	"	"	"	"	HCV-I	121	89.82	$39,671	89.36
	"	"	"	"	"	HCV-II	151	118.77	$65,460	118.21
	3	Days	All	All	365	Car	2082	13.84	$105,205	13.15
	"	"	"	"	"	LCV	243	10.95	$9,710	10.21
	"	"	"	"	"	MCV	135	20.55	$10,125	19.18
	"	"	"	"	"	HCV-I	121	26.62	$11,755	23.79
	"	"	"	"	"	HCV-II	151	30.02	$16,545	27.19
DO MINIMUM - Southbound (Continued)				AADT = 5464		(Yr 2)				
	4	Days	All	All	365	Car	2082	21.75	$165,307	20.97
	"	"	"	"	"	LCV	243	18.62	$16,518	17.79
	"	"	"	"	"	MCV	135	36.08	$17,778	34.62
	"	"	"	"	"	HCV-I	121	52.77	$23,306	49.81
	"	"	"	"	"	HCV-II	151	74.16	$40,872	71.15
	5	Days	All	All	365	Car	2082	11.11	$84,406	10.67
	"	"	"	"	"	LCV	243	8.84	$7,841	8.38
	"	"	"	"	"	MCV	135	17.26	$8,507	16.49
	"	"	"	"	"	HCV-I	121	23.12	$10,210	21.55
	"	"	"	"	"	HCV-II	151	27.92	$15,386	26.31
	6	Days	All	All	365	Car	2082	26.43	$200,825	25.36
	"	"	"	"	"	LCV	243	20.78	$18,427	19.65
	"	"	"	"	"	MCV	135	59.43	$29,282	57.52
	"	"	"	"	"	HCV-I	121	98.96	$43,704	95.12
	"	"	"	"	"	HCV-II	151	153.10	$84,383	149.17
DO MINIMUM - Southbound (Continued)				AADT = 5464		(Yr 2)				
	7	Days	All	All	365	Car	2082	11.10	$84,389	10.67
	"	"	"	"	"	LCV	243	8.84	$7,840	8.38
	"	"	"	"	"	MCV	135	21.60	$10,644	20.82
	"	"	"	"	"	HCV-I	121	34.15	$15,083	32.59
	"	"	"	"	"	HCV-II	151	51.16	$28,198	49.55
	8	Days	All	All	365	Car	2082	29.58	$224,820	28.38
	"	"	"	"	"	LCV	243	23.64	$20,964	22.36
	"	"	"	"	"	MCV	135	44.61	$21,982	42.45
	"	"	"	"	"	HCV-I	121	57.03	$25,185	52.68
	"	"	"	"	"	HCV-II	151	66.16	$36,465	61.70
	Total Annual VOC - Southbound (Car, LCV, MCV)							=	**$1,586,058**	
	Total Annual VOC - Southbound (HCV-I, HCV-II)								**$503,711**	2,089,769
Total Annual VOC - Southbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,539,397	
Total Annual VOC - Southbound (HCV-I, HCV-II) (excluding Roughness Costs)									$485,797	2,025,194
=> Total Annual Carbon Dioxide Emission Cost - Southbound (Car, LCV, Mcv)								=	**$69,273**	
=> Total Annual Carbon Dioxide Emission Cost - Southbound (HCV-I, HCV-II)									**$21,861**	91,134

Option	Section/ Movement	Time Units	Period		Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughnes (cents)
			From	To						
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
DO MINIMUM - Northbound			AADT = 5464			(Yr 2)				
	1	Days	All	All	365	Car	2082	17.17	$130,468	17.02
	"	"	"	"	"	LCV	243	13.93	$12,352	13.77
	"	"	"	"	"	MCV	135	27.47	$13,538	27.33
	"	"	"	"	"	HCV-I	121	35.83	$15,822	35.54
	"	"	"	"	"	HCV-II	151	43.25	$23,838	42.91
	2	Days	All	All	365	Car	2082	37.34	$283,761	37.01
	"	"	"	"	"	LCV	243	29.45	$26,121	29.10
	"	"	"	"	"	MCV	135	55.23	$27,216	54.90
	"	"	"	"	"	HCV-I	121	68.86	$30,410	68.21
	"	"	"	"	"	HCV-II	151	80.06	$44,124	79.27
	3	Days	All	All	365	Car	2082	15.41	$117,088	14.97
	"	"	"	"	"	LCV	243	13.00	$11,532	12.54
	"	"	"	"	"	MCV	135	25.80	$12,711	25.12
	"	"	"	"	"	HCV-I	121	36.82	$16,262	35.52
	"	"	"	"	"	HCV-II	151	51.49	$28,380	50.09
DO MINIMUM - Northbound (Continued)			AADT = 5464			(Yr 2)				
	4	Days	All	All	365	Car	2082	17.91	$136,092	17.32
	"	"	"	"	"	LCV	243	14.09	$12,494	13.46
	"	"	"	"	"	MCV	135	28.44	$14,012	27.52
	"	"	"	"	"	HCV-I	121	38.18	$16,863	36.41
	"	"	"	"	"	HCV-II	151	48.27	$26,603	46.37
	5	Days	All	All	365	Car	2082	12.88	$97,848	12.17
	"	"	"	"	"	LCV	243	10.87	$9,638	10.11
	"	"	"	"	"	MCV	135	21.62	$10,653	20.12
	"	"	"	"	"	HCV-I	121	31.69	$13,996	28.55
	"	"	"	"	"	HCV-II	151	42.86	$23,623	39.79
	6	Days	All	All	365	Car	2082	35.26	$267,970	33.53
	"	"	"	"	"	LCV	243	31.00	$27,493	29.16
	"	"	"	"	"	MCV	135	64.29	$31,680	60.63
	"	"	"	"	"	HCV-I	121	101.85	$44,984	94.16
	"	"	"	"	"	HCV-II	151	155.07	$85,469	147.55
DO MINIMUM - Northbound (Continued)			AADT = 5464			(Yr 2)				
	7	Days	All	All	365	Car	2082	14.15	$107,546	13.44
	"	"	"	"	"	LCV	243	12.32	$10,928	11.57
	"	"	"	"	"	MCV	135	24.54	$12,090	23.04
	"	"	"	"	"	HCV-I	121	38.12	$16,834	34.98
	"	"	"	"	"	HCV-II	151	56.51	$31,145	53.44
	8	Days	All	All	365	Car	2082	34.62	$263,122	32.66
	"	"	"	"	"	LCV	243	29.84	$26,464	27.75
	"	"	"	"	"	MCV	135	56.54	$27,862	52.39
	"	"	"	"	"	HCV-I	121	80.77	$35,673	72.06
	"	"	"	"	"	HCV-II	151	104.71	$57,713	96.19
	Total Annual VOC - Northbound (Car, LCV, MCV)							=	**$1,690,678**	
	Total Annual VOC - Northbound (HCV-I, HCV-II)								**$511,741**	2,202,419
Total Annual VOC - Northbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,627,856	
Total Annual VOC - Northbound (HCV-I, HCV-II) (excluding Roughness Costs)									$485,277	2,113,133
=> Total Annual Carbon Dioxide Emission Cost - Northbound (Car, LCV, Mcv)								=	**$73,254**	
=> Total Annual Carbon Dioxide Emission Cost - Northbound (HCV-I, HCV-II)									**$21,837**	95,091

VEHICLE OPERATING COSTS B: WORKSHEET A5.2

Option	Section/ Movement	Time Units	Period		Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughnes (cents)
			From	To						
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
REALIGNMENT OPTIONS - Southbound			AADT = 5464			(Yr 2)				
	1	Days	All	All	365	Car	2082	11.71	$89,022	11.64
	"	"	"	"	"	LCV	243	10.12	$8,978	10.05
	"	"	"	"	"	MCV	135	18.12	$8,927	18.05
	"	"	"	"	"	HCV-I	121	23.73	$10,479	23.59
	"	"	"	"	"	HCV-II	151	28.77	$15,855	28.60
	2	Days	All	All	365	Car	2082	41.04	$311,849	40.80
	"	"	"	"	"	LCV	243	35.23	$31,243	34.97
	"	"	"	"	"	MCV	135	64.39	$31,729	64.15
	"	"	"	"	"	HCV-I	121	86.72	$38,301	86.26
	"	"	"	"	"	HCV-II	151	111.77	$61,602	111.21
	3	Days	All	All	365	Car	2082	12.91	$98,101	12.82
	"	"	"	"	"	LCV	243	10.28	$9,116	10.19
	"	"	"	"	"	MCV	135	18.94	$9,331	18.85
	"	"	"	"	"	HCV-I	121	23.30	$10,291	23.14
	"	"	"	"	"	HCV-II	151	26.45	$14,579	26.25
REALIGNMENT OPTIONS - Southbound (Continu			AADT = 5464			(Yr 2)				
	4	Days	All	All	365	Car	2082	21.12	$160,491	21.00
	"	"	"	"	"	LCV	243	18.52	$16,423	18.39
	"	"	"	"	"	MCV	135	34.91	$17,201	34.79
	"	"	"	"	"	HCV-I	121	50.30	$22,215	50.08
	"	"	"	"	"	HCV-II	151	71.49	$39,399	71.21
	5	Days	All	All	365	Car	2082	10.18	$77,343	10.11
	"	"	"	"	"	LCV	243	8.00	$7,099	7.93
	"	"	"	"	"	MCV	135	15.93	$7,848	15.86
	"	"	"	"	"	HCV-I	121	20.56	$9,082	20.43
	"	"	"	"	"	HCV-II	151	25.05	$13,805	24.89
	6	Days	All	All	365	Car	2082	24.82	$188,640	24.66
	"	"	"	"	"	LCV	243	19.34	$17,150	19.16
	"	"	"	"	"	MCV	135	50.52	$24,892	50.35
	"	"	"	"	"	HCV-I	121	82.34	$36,366	82.02
	"	"	"	"	"	HCV-II	151	134.63	$74,204	134.24
REALIGNMENT OPTIONS - Southbound (Continu			AADT = 5464			(Yr 2)				
	7	Days	All	All	365	Car	2082	10.13	$76,996	10.06
	"	"	"	"	"	LCV	243	7.89	$7,000	7.82
	"	"	"	"	"	MCV	135	18.12	$8,929	18.05
	"	"	"	"	"	HCV-I	121	27.23	$12,025	27.10
	"	"	"	"	"	HCV-II	151	41.65	$22,957	41.49
	8	Days	All	All	365	Car	2082	23.41	$177,885	23.26
	"	"	"	"	"	LCV	243	18.87	$16,736	18.71
	"	"	"	"	"	MCV	135	34.16	$16,832	34.01
	"	"	"	"	"	HCV-I	121	41.47	$18,317	41.18
	"	"	"	"	"	HCV-II	151	46.65	$25,709	46.29
	Total Annual VOC - Southbound (Car, LCV, MCV)							=	**$1,419,760**	
	Total Annual VOC - Southbound (HCV-I, HCV-II)								**$425,186**	1,844,946
Total Annual VOC - Southbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,411,039	
Total Annual VOC - Southbound (HCV-I, HCV-II) (excluding Roughness Costs)									$423,106	1,834,145
=> Total Annual Carbon Dioxide Emission Cost - Southbound (Car, LCV, Mcv)								=	**$63,497**	
=> Total Annual Carbon Dioxide Emission Cost - Southbound (HCV-I, HCV-II)									**$19,040**	82,537

VEHICLE OPERATING COSTS B: WORKSHEET A5.2

Option	Section/ Movement	Time Units	Period From	Period To	Time Units per Year	Vehicle Type	Vehicles per Time Unit	Section Cost (cents)	Total Cost per Year ($)	Section Cost (excl. Roughnes (cents)
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(8)
REALIGNMENT OPTIONS - Northbound				AADT = 5464		(Yr 2)				
	1	Days	All	All	365	Car	2082	11.10	$84,369	11.03
	"	"	"	"	"	LCV	243	9.15	$8,113	9.07
	"	"	"	"	"	MCV	135	17.09	$8,420	17.02
	"	"	"	"	"	HCV-I	121	20.99	$9,268	20.85
	"	"	"	"	"	HCV-II	151	21.94	$12,093	21.78
	2	Days	All	All	365	Car	2082	36.93	$280,680	36.70
	"	"	"	"	"	LCV	243	29.66	$26,306	29.41
	"	"	"	"	"	MCV	135	53.80	$26,511	53.56
	"	"	"	"	"	HCV-I	121	65.37	$28,869	64.90
	"	"	"	"	"	HCV-II	151	71.92	$39,641	71.36
	3	Days	All	All	365	Car	2082	14.82	$112,609	14.73
	"	"	"	"	"	LCV	243	12.78	$11,339	12.69
	"	"	"	"	"	MCV	135	23.86	$11,759	23.78
	"	"	"	"	"	HCV-I	121	32.83	$14,498	32.66
	"	"	"	"	"	HCV-II	151	43.54	$23,995	43.34
REALIGNMENT OPTIONS - Northbound (Continu				AADT = 5464		(Yr 2)				
	4	Days	All	All	365	Car	2082	17.25	$131,050	17.13
	"	"	"	"	"	LCV	243	13.49	$11,965	13.37
	"	"	"	"	"	MCV	135	27.63	$13,616	27.52
	"	"	"	"	"	HCV-I	121	36.63	$16,179	36.41
	"	"	"	"	"	HCV-II	151	46.64	$25,705	46.37
	5	Days	All	All	365	Car	2082	12.20	$92,706	12.13
	"	"	"	"	"	LCV	243	10.64	$9,436	10.57
	"	"	"	"	"	MCV	135	20.19	$9,950	20.12
	"	"	"	"	"	HCV-I	121	28.68	$12,668	28.55
	"	"	"	"	"	HCV-II	151	39.95	$22,018	39.79
	6	Days	All	All	365	Car	2082	34.04	$258,645	33.87
	"	"	"	"	"	LCV	243	30.50	$27,050	30.32
	"	"	"	"	"	MCV	135	60.79	$29,956	60.63
	"	"	"	"	"	HCV-I	121	94.48	$41,729	94.16
	"	"	"	"	"	HCV-II	151	147.94	$81,536	147.55
REALIGNMENT OPTIONS - Northbound (Continu				AADT = 5464		(Yr 2)				
	7	Days	All	All	365	Car	2082	13.36	$101,522	13.29
	"	"	"	"	"	LCV	243	11.90	$10,552	11.82
	"	"	"	"	"	MCV	135	23.11	$11,386	23.04
	"	"	"	"	"	HCV-I	121	35.11	$15,506	34.98
	"	"	"	"	"	HCV-II	151	53.60	$29,540	53.44
	8	Days	All	All	365	Car	2082	26.97	$204,987	26.82
	"	"	"	"	"	LCV	243	23.63	$20,956	23.46
	"	"	"	"	"	MCV	135	42.63	$21,008	42.48
	"	"	"	"	"	HCV-I	121	58.72	$25,935	58.43
	"	"	"	"	"	HCV-II	151	78.35	$43,183	77.99
	Total Annual VOC - Northbound (Car, LCV, MCV)							=	**$1,524,889**	
	Total Annual VOC - Northbound (HCV-I, HCV-II)								**$442,362**	1,967,252
Total Annual VOC - Northbound (Car, LCV, MCV) (excluding Roughness Costs)								=	$1,516,169	
Total Annual VOC - Northbound (HCV-I, HCV-II) (excluding Roughness Costs)									$440,282	1,956,451
=> Total Annual Carbon Dioxide Emission Cost - Northbound (Car, LCV, Mcv)								=	**$68,228**	
=> Total Annual Carbon Dioxide Emission Cost - Northbound (HCV-I, HCV-II)									**$19,813**	88,040